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RESEARCH
AND
TECHNOLOGY

1983
Annual Report
of the
Kennedy Space Center
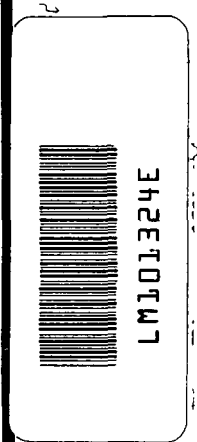
NASA

National Aeronautics and
Space Administration

John F. Kennedy Space Center
Kennedy Space Center, Florida 32899

FOREWORD

As the NASA Center responsible for assembly, checkout, servicing, launch, recovery, and operational support of Space Transportation System elements and payloads, Kennedy Space Center is placing increasing emphasis on the Center's research and technology program. In addition to strengthening those areas of engineering and operations technology that contribute to safer, more efficient, and more economical execution of our current mission, we are developing the technological tools needed to execute the Center's mission relative to Space Station and other future programs. In connection with the increasing emphasis on research and technology, the directorate of Design Engineering has been expanded in scope and is now designated the directorate of Engineering Development. The new directorate encompasses most of the laboratories and other Center resources that are key elements of research and technology program implementation and is responsible for implementation of the majority of the projects in this Kennedy Space Center 1983 Annual Report. The report contains brief descriptions of research and technology projects in major areas of Kennedy Space Center's disciplinary expertise.

For further technical information about the projects, contact Albert E. Jorolan, Engineering Development, Research and Technology Manager, DL-RT, (305) 867-7476. James M. Spears, Chief, Technology Projects Office, PT-TPO, (305) 867-7705, is responsible for publication of this report and should be contacted for any desired information regarding the Center-wide research and technology program.

Richard G. Smith
Director

AVAILABILITY INFORMATION

For additional information on any summary, contact the individual identified with the highlight. Commercial telephone users may dial the listed extension preceded by (305). Telephone users with access to the Federal Telecommunications System (FTS) may dial the extension preceded by 823.

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PROJECT REFERENCE DATA

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Magnetic Reliquefaction of Hydrogen

Under a Kennedy Space Center (KSC) contract initially funded from the KSC Center Director's 1982 discretionary fund, Los Alamos National Laboratories has been in the process of developing the technology of refrigeration by magnetism. The purpose of this project is to provide a more thermodynamically efficient system than those using compressors and expanders. The ultimate goal of the magnetic refrigerator is to chill hydrogen gas from ambient temperature to liquid temperature The principle of the system is to use the magneto-caloric effect of heating/cooling of a magnetic material upon application/removal of a magnetic field at the curie temperature of the magnetic material to which the gas is exposed. The application and removal of the magnetic field is more efficient than the classical method of applying and removing pressure from a gas using a compressor and expander. The magnetism can provide a temperature change of approximately 2K/T.

In the initial development phase of a refrigeration unit, it is desirable to limit the temperature range of refrigeration to minimize the number of materials required with specific curie temperatures. Development of a liquid hydrogen boiloff liquefaction unit requires a much narrower temperature range than would a liquefaction unit operating between ambient and liquid temperatures
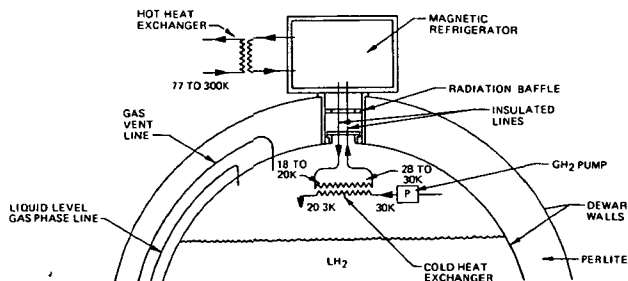
A schematic diagram of the simplest magnetic reliquefier options where the liquefier is located on top of the large storage dewar.

During initial development of the KSC refrigeration system, analyses of the refrigeration requirements and the refrigerator options were made.

Measurements were also made of the magnetic properties of potential gadolinium compounds to be used in the refrigerator. Properties measured were density, magnetic susceptibility, heat capacity, and adiabatic temperature change.

Results of magnetic susceptibility measurements for gadolinium nickel as a function of temperature show that the sharp rise in susceptibility is a good indication of ferromagnetic order. The dual trace results from sweeping temperature down and up. The magnetic properties determined are being used to develop the refrigeration unit design.

F. S. Howard, 867-3202   DD-MED-4
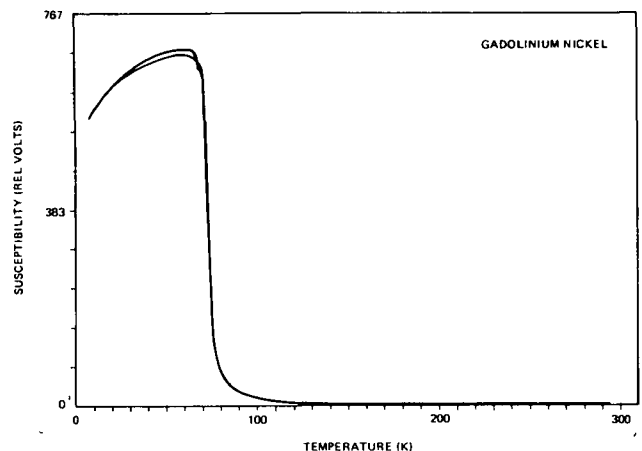
The relative magnetic susceptibility of gadolinium nickel as a function of temperature.

Capture of Liquid Hydrogen (LH2) Boiloff Using Metal Hydrides

Future Space Shuttle launch requirements at Kennedy Space Center (KSC) will require an LH_2 production rate of 12 tons per day. During Shuttle processing, much of the LH_2 is lost by being boiled away during vehicle processing. Up to 2 tons per day of hydrogen gas may be economically capturable by installing metal-hydride capture systems at Launch Complex 39 Pads A and B.

Currently, KSC has a study contract with Ergenics of Wyckoff, New Jersey, to develop a proof-of-concept unit and to demonstrate the unit at KSC. The task includes establishing system performance requirements and performing hydride container design, alloy container design verification, hydride alloy manufacture, container and system assembly, and system test

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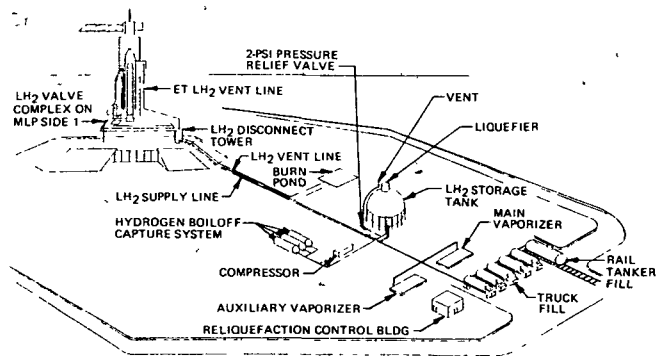
Proposed hydrogen boiloff capture system location.
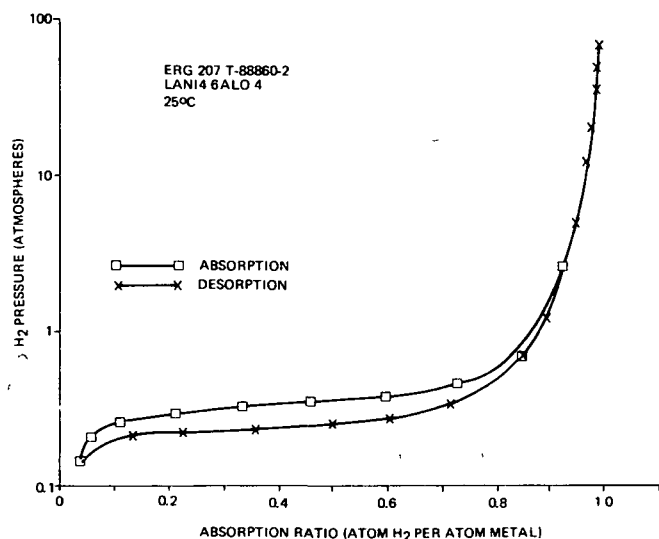
Absorption and desorption plot for metal hydride selected.

The proposed location for the hydrogen boil-off capture system is adjacent to the LH_2 storage tank. Tests of various hydrides have shown that an alloy composed of lanthanum, nickel, and aluminum provides absorption and desorption properties at the low pressure required. The metal hydride can be cooled with ambient temperature water while hydrogen is being absorbed. Hydrogen will be driven out of the hydride into the liquefier with heat from warm water. The demonstration test unit is under construction and will be tested in December 1983.

The results of this effort will be integrated into a preliminary design of the full-scale unit. The results will also be evaluated for possible use in industry and Space Station applications

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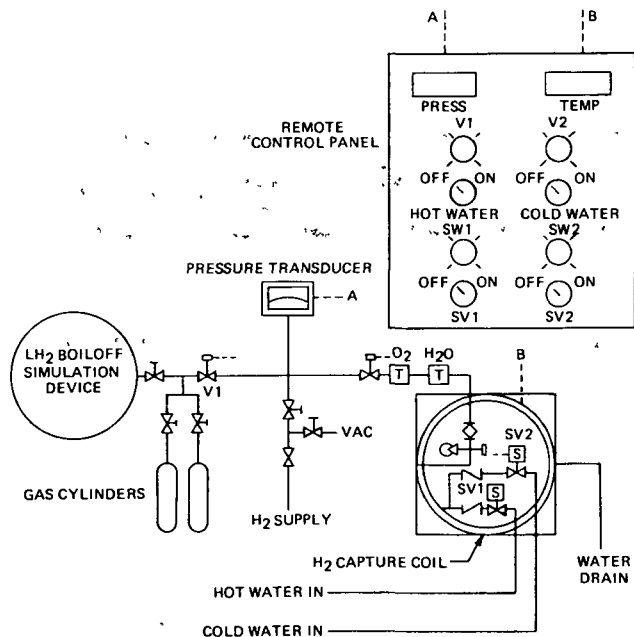
Demonstration test model simplified schematic.

Study of Systems and Technology for Liquid Hydrogen Production Independent of Fossil Fuels

NASA uses a sizeable fraction of the nation's production of liquid hydrogen as a fuel for Space Shuttle, Centaur, and engine testing and as a fuel cell reactant Kennedy Space Center is the principal user, with its supply presently coming from the New Orleans area. There, Air Products Incorporated operates a plant to supply NASA's needs under a contract from the Marshall Space Flight Center. The feedstock used is natural gas, which is reformed by steam to produce hydrogen and carbon dioxide. Other conventional hydrogen mass production schemes have employed the conversion of naphtha, fuel oil, or coal. Electrolysis of water has also been competitive for narrow or restricted markets.

It is, of course, attractive from a conservation and, probably, from an ecological standpoint to make hydrogen from a totally renewable resource. The principal deterrent is the questionable economic noncompetitiveness of a nonfossil fuel process at the present time and into the immediate future. This study was intended to examine how soon technological maturity would make some of the numerous processes for producing hydrogen economically competitive. The study used mile-

stones of 1987, 1992, and 2000 or beyond as targets of opportunity to examine relative maturity and projected costs for construction, operations, and feedstocks. The hydrogen use rate was baselined at 10^6 gal/year, and byproduct credit was considered where feasible.

Solar, thermionic, thermoelectric, thermal catalytic, photoelectrolytic, photoelectrocatalytic, photolytic, photocatalytic, geothermal, biological, biomass conversion, wind, and ocean energy processes were examined. After two levels of screening, the two processes selected for a detailed conceptual design were both solar. One was solar photovoltaic, with conventional electrolysis; the other was a power tower (solar central receiver) similar to Solar 100. Both these systems were predicted to be economically competitive with systems using fossil fuels after 1992, subject to assumptions on escalation of fossil fuel costs and market drive cost improvement of some key solar system cost elements (photovoltaic cells and heliostats)

This study was performed by E·F Technology of St. Johns, Michigan.

W. H. Boggs, 867-2133   DD-FED
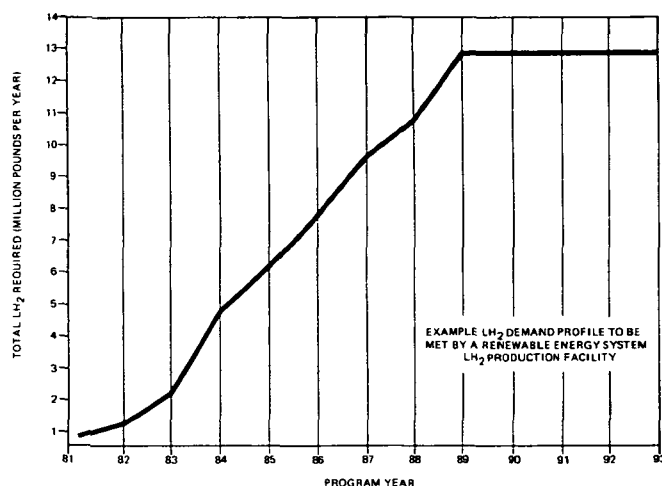
Anticipated KSC liquid hydrogen requirements.

Flex Hose Flow-Induced Vibration Testing

Flex hoses are used for critical functions throughout the main propulsion liquid oxygen and liquid hydrogen systems and may fail because of flow-induced vibration. The analytical method described in JSC 08132, "Certification of Flex Hoses and Bellows for Flow Induced Vibration," is too conservative and could cause uncertainty and unnecessary modification to the propellant loading system.

Immediately after the Space Transportation System flight no. 1 tanking test conducted on January 24, 1981, the main propulsion liquid hydrogen system venting requirement was changed. This rate increased the gas flow through the system. Based on the new flow rate, the analytical method described in JSC 08132 predicted a very short life for an 8-in flex hose in the vent system. To certify this flex hose for the new flow rate, a series of tests were conducted at Kennedy Space Center on a similar 8-in flex hose. These tests indicated that the 8-in flex hose in the vent system should have a much longer service life.
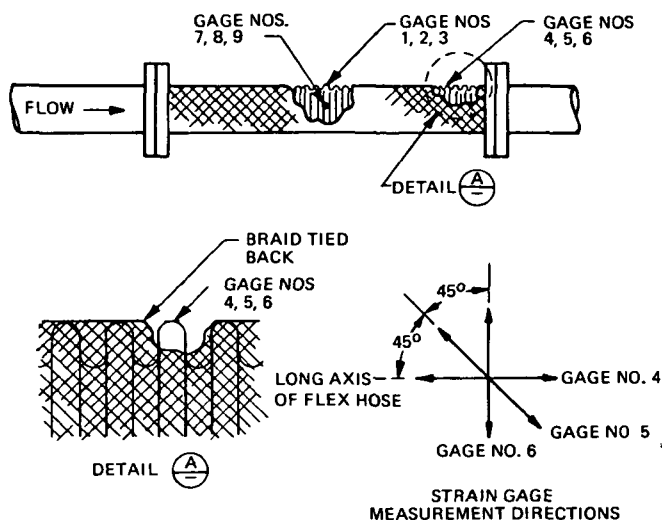
Strain gage locations and orientation on flex hose

Recently, more tests were conducted on the same 8-in test hose to gather data on stress and fatigue life at different flow-induced vibration modes. At the vibration mode corresponding to a Mach no. of 0.33, the stress predicted by the method in JSC 08132 was higher than the measured stress by a factor of approximately 25. In terms of fatigue life, the measured stresses indicate that the flex hose may survive flow rates at Mach 0.33 for hours, whereas the predicted stress implies a fatigue life of less than 10 s.

In May 1983, Kennedy Space Center awarded a 12-month research contract to the Georgia Institute of Technology. The contract objective is, using the available Kennedy Space Center test data, to develop a method to easily and accurately predict stresses within bellows or flex hoses at various flow-induced vibration modes.

F. N. Lin, 867-4156   DD-MED-4

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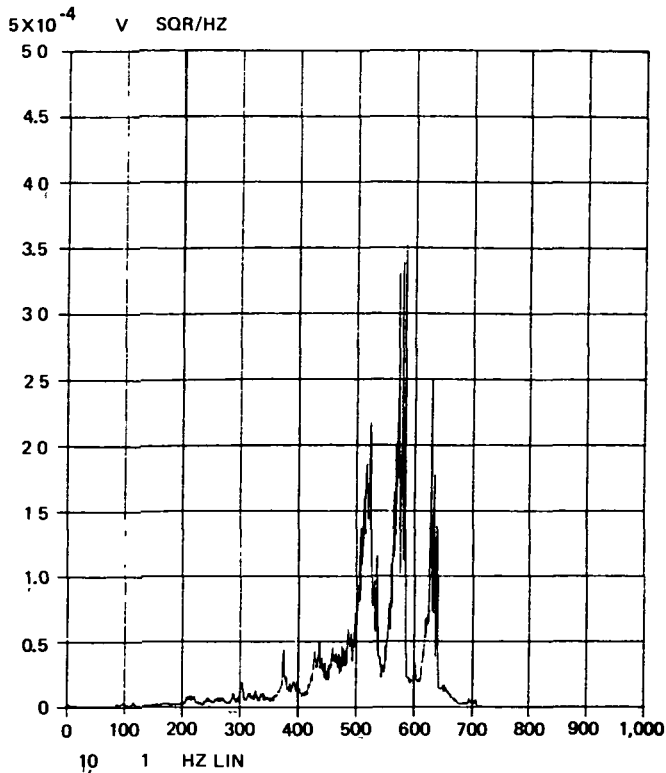
Power spectral density analysis of data recorded by accelerometer at Mach 0.26.

a study to develop a mathematical model for predicting pressure spikes in a two-phase LO_2 system. Comparing the predicted spikes with the loading data at the skid outlet shows that the predicted peaks occur too early and the theoretical time interval between the two peaks is smaller than the measured one. Additionally, the predicted maximum peak pressure is higher than the measured value Additional work will be done to refine the model.

F. N. Lin, 867-4156   DD-MED-4
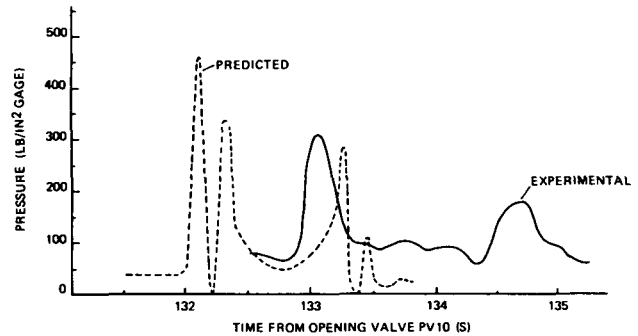
Comparison with test data at the skid outlet for two-phase flow.

Mathematical Model for Estimating Transient Pressure Surges in Cryogenic Liquid-Vapor Systems

The Space Shuttle liquid oxygen (LO_2) servicing system is designed to transfer LO_2 between the ground storage tank and the Shuttle external tank. Since the LO_2 is transferred at conditions close to saturation, a small reduction in local pressure could form a vapor cavity. The subsequent collapse of any cavity may result in pressure spikes through the system.

During Space Transportation System LO_2 tanking operations, undesirable pressure spikes have been experienced and recorded These pressure spikes can be eliminated or minimized if a proper operational procedure is available. To provide a proper procedure, a transient flow analysis is often required for each operational mode. Although methods for predicting pressure spikes in a liquid system have been well developed, methods for a liquid-vapor system have not Consequently, Kennedy Space Center, in conjunction with the University of Central Florida, has initiated

Computer Simulation of External Tank (ET) Liquid Oxygen (LO2) Vent System

During loading of the LO_2 ET for the first launch of the Space Shuttle, leakage occurred around the gaseous oxygen (GO_2) vent seals due to unexpected high pressure surges. This leakage was
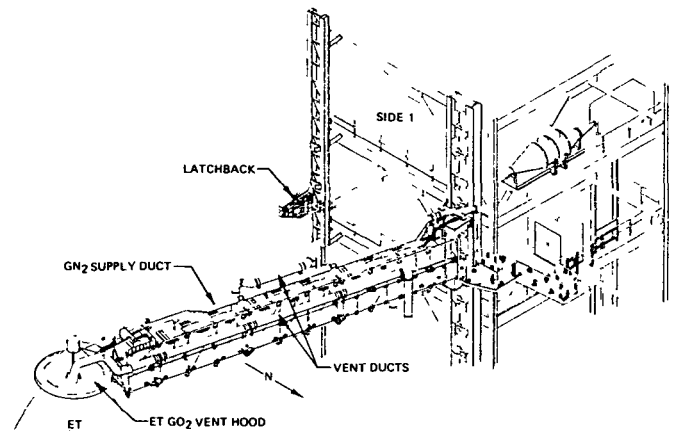
ET GO_2 vent system overall view.
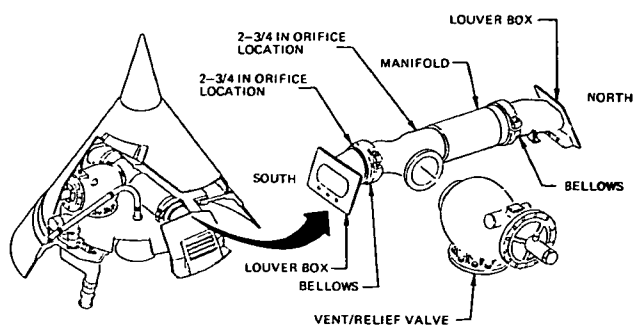
ET GO_2 vent system onboard view.
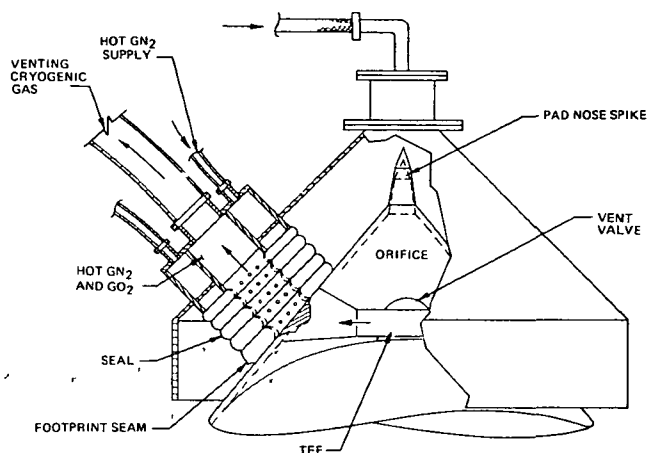
ET GO_2 vent system dock seal orientation.

ET GO_2 vent system seal cavity backpressure dual tanking test no. 1, first cycle.

a problem because of the possibility of ice forming on the ET due to the cold gas impinging on the surface of the ET.

The ET GO_2 ground support vent system was used to vent excess pressure from the ET during loading of LO_2 for the STS-1 launch. The system vent configuration consists of a vent/relief valve, a tee junction branching to louvers located on opposite sides of the ET, inflatable seals held over the louvers, and approximately 60 ft of piping from each louver to carry the oxygen vapor away from the tank. A model of this system was developed using the gas transients (GTRAN) computer program to determine the transient pressure spikes associated with the fast opening time of the vent valve. Gaseous nitrogen at 200°F was used to fill the vent ducts prior to opening the vent valve. Two simulated cases were run, one assuming 70°F gaseous helium venting from the tank and the other 70°F GO_2. This was done because of a helium purge located at the top of the tank and the unknown mixture of GO_2 and gaseous helium that

would be vented during opening of the vent valve. A comparison of the pressure transient occurring in the inflatable seals and the results of the simulation of the vent system was made to determine the underlying cause of the high surge pressures. The simulation of the vent system using the GTRAN program defined the problem areas, provided baseline data for the redesign of the system, and was used to verify the final design that ultimately solved the problem.

The GTRAN program, developed at Kennedy Space Center and used for this analysis, is a generalized computer program capable of solving both transient and steady-state gaseous fluid flow problems. The program includes friction, heat transfer, and compressibility effects on networks of pipes and has a general set of boundary conditions to simulate valves and orifices, choked-flow conditions, branching, tanks and reservoirs, and constant mass flow rate conditions.

The unique feature of this program is its ability to account for compressibility effects on the solution of transient and steady-state fluid flows. The conditions of numerical stability of the program required the use of a more stable, implicit finite-difference equation rather than the explicit scheme of a previous liquid transient analysis. This improved stability allows it to reach a solution when the velocities are a significant fraction of the speed of sound, although the program is not capable of supersonic or shock calculations.

The GTRAN program is written in FORTRAN and is modular enough to make it simple to include specific boundary conditions for specialized components.

A. F. Rodriquez, 867-3339   DD-MED-43

Cryogenic Quick-Disconnect (QD) Coupling Development

Cryogenic QD couplings are used to transfer liquid hydrogen or liquid oxygen across the interface between ground support and launch vehicle propellant piping systems. As their name implies, these couplings must quickly disengage from the launch vehicle at the instant of lift-off. While engaged, the couplings must provide the best possible barrier against heat leakage into the propellant and propellant leakage out of the system with minimal restriction of propellant flow. During disconnect, the two halves of the coupling must disengage in a fraction of a second without binding or imparting excessive loads on the launch vehicle.

State-of-the-art cryogenic QD's require technicians on site to connect the couplings manually prior to propellant transfer. During propellant transfer, heat leaks into the propellant and propellant leakage out of the QD are frequent problems.

Recent research and development activities at KSC are aimed at producing a vacuum-insulated, zero-leak, cryogenic QD with a capability for being connected by remote control. A key milestone in this effort is the development of a better seal that is compatible with combustible cryogenic liquids Concepts are evolving from the use of novel designs and materials to produce a seal that is leakproof by virtue of being resistant to damage during engagement and tolerant of misalignment or damage at the sealing surfaces.

One promising concept uses a thin polymer radial seal that does not contact the sealing surface during QD engagement but is inflated by high-pressure gas to expand radially when sealing is required. The radial expansion of the seal closes the propellant leak path by forming a tight fit against the opposing seal surface. Other seal designs under consideration use more exotic seal materials, such as ferrofluids and shape-memory alloys, to meet the stringent requirements of cryogenic propellant service.

By combining the advantages of improved seal technology, vacuum insulation, and remote-controlled engagement and disengagement, a new cryogenic QD design will emerge with the revolutionary capabilities required to meet the future needs of the space program.

G. E. Reichle, 867-7585   DD-MED-31
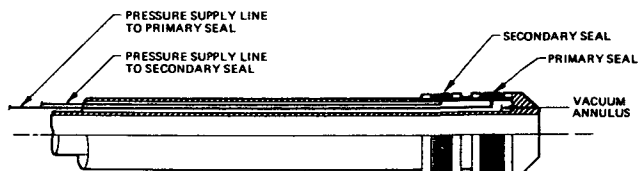
Male bayonet with inflatable seals.

Hypergolic Engineering

Hypergolic Packed-Column Counterflow Vapor Scrubber Test Program

The Kennedy Space Center (KSC) currently uses packed-column counterflow scrubbers to cleanse toxic hypergolic vapor contained in vent streams produced during Space Shuttle Orbiter propellant loading, deservicing, and checkout operations. The orbital maneuvering subsystem and reaction control subsystems use bipropellant products for on-orbit operation consisting of nitrogen tetroxide (oxidizer) and monomethylhydrazine (fuel). Additionally, the onboard auxiliary power unit uses monopropellant hydrazine to support onboard hydraulic and electrical subsystems.
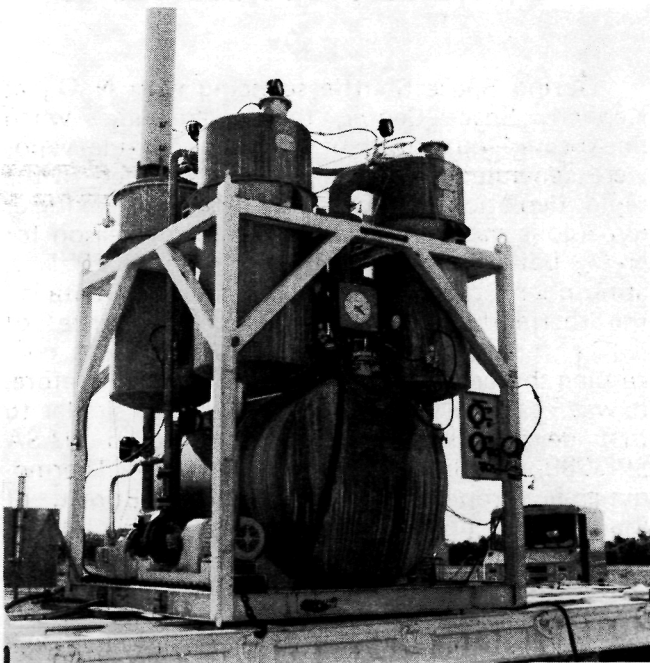
Oxygen vapor scrubber test-bed

The ground support equipment and facilities required to support these operations use packed-column counterflow vapor scrubbers to cleanse the respective oxidizer and fuel vapor products con-

tained in inert gas vent streams. The oxidizer vapor scrubber uses a 25-percent caustic or sodium hydroxide aqueous solution to chemically react and destroy the mixed oxides of nitrogen vapor products from oxidizer systems. The fuel vapor scrubber uses plain water or a 14-percent citric acid aqueous solution to contain or destroy the hypergolic vapor products from fuel systems. These units have been in operation for approximately 6 years, and emission performance is considered state-of-the-art. Improvements are continually being sought to reduce detectable emissions.

Currently, a KSC test program is in progress to reevaluate existing system design and to test new and improved packed-column internals based on coordination and consultation with companies in the scrubber packing field.
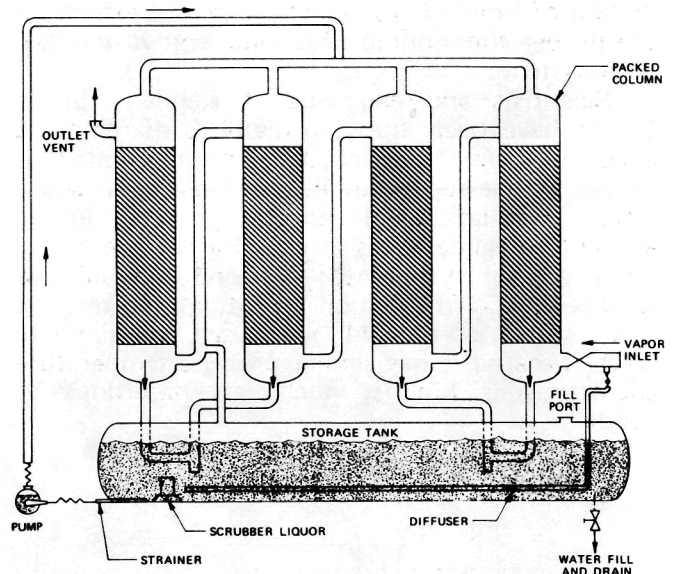
Toxic vapor scrubber diagram (packed-column counterflow).

Parallel to the in-house effort, KSC recently awarded a 12-month contract to Research Triangle Institute, Research Triangle Park, North Carolina, to study and evaluate alternate control technologies in two phases: information gathering and evaluation. This effort will involve contacting manufacturers and users to identify potentially suitable catalysts, conducting laboratory studies, and evaluating feasible concepts.

The KSC goal is to identify optimum state-of-the-art control technology for hypergolic vapor emission destruction and to incorporate this technology in the hypergolic systems located in the KSC and Vandenberg Air Force Base Shuttle facilities.

H. E. Peete, 867-3206   DD-MED-41

7

Distillation and Recovery Processing of Nitrogen Tetroxide (N2O4)

N_2O_4 is a constituent of the bipropellant used to power the orbital maneuvering subsystem and reaction control subsystem engines. N_2O_4 is loaded into the Orbiter in liquid form and provides the oxygen necessary to support a hypergolic reaction with monomethylhydrazine.

N_2O_4 is a very strong oxidizer and will react with many substances. This trait creates problems when N_2O_4 is stored prior to transfer on board the Orbiter. The corrosive nature of this oxidizer is such that it will attack the stainless steel vessels in which it is stored, leeching iron out of the vessel and into solution in the oxidizer. Although the rate of attack is very slow, as few as 2 to 6 parts per million of iron in N_2O_4 can have serious effects on the proper functioning of components in the oxidizer system.

Scientists and engineers at Kennedy Space Center have been studying methods of removing dissolved iron from N_2O_4. One method that proved to be successful in the laboratory was a simple distillation-and-recovery process. In an attempt to validate this process for Shuttle operations, a pilot system was designed and built to simulate N_2O_4 distillation operations. To test the pilot system, Freon-11 was used to simulate N_2O_4 because it has similar pressure/temperature characteristics but is much less hazardous to handle.
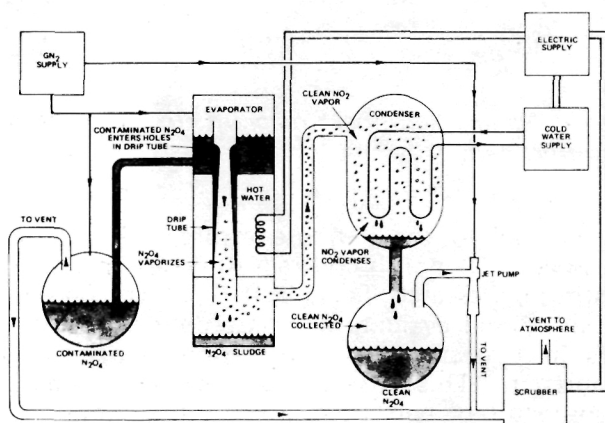
N_2O_4 distillation test system.

The pilot distillation system consisted of a supply tank, an evaporator, a condenser, and a receiving tank. The contaminated liquid was pressure-transferred to the evaporator, which was of the falling-film type. The contaminated liquid fell down heated tubes as a thin film and evaporated, leaving the contaminant solids to accumulate in the evaporator. Gas from the evaporator was carried by pressure gradient to the condenser, where it condensed in the form of purified liquid. The pilot system was designed to operate in either an open-and-vented or closed-vent configuration. At peak operational capacity, the pilot system purified more than 3 gal of Freon-11 per hour. The limiting factor in the system was the number of tubes in the evaporator.

This test system provided information concerning the operational feasibility of high-capacity N_2O_4 distillation systems and established a basis for comparison with other types of N_2O_4 purification systems that are currently under consideration.

K. S. Ahmie, 867-7960   DD-MED-41

Nitrogen Tetroxide (N2O4) Thermophysical Properties Tables

During Space Shuttle servicing with N_2O_4 at Kennedy Space Center, there were times when unexpected quantities of nitrogen dioxide vapor were generated by N_2O_4 boiloff. This led to the rapid depletion of scrubbing liquor in oxidizer hypergolic vapor scrubbers. The prime reason for N_2O_4 boiloff is that its boiling point is 70°F at atmospheric pressure. Because of limited data on the thermodynamic and transport properties of N_2O_4, it was difficult to make calculations concerning this and similar N_2O_4 problems. Therefore, it was desirable to develop tabular data similar to that developed for cryogenic media in NASA SP-3089, "Hydrogen Technical Survey — Thermodynamic Properties." The National Bureau of Standards is now developing these N_2O_4 tabular data.

In the development of the math model for these data, the greatest area of uncertainty was the saturation curve. This area of uncertainty has been resolved. The resolution is a key building block for the mathematical model for the remainder of the tabular data. The thermodynamic properties tables for N_2O_4 will be completed by January 1984.

F. S. Howard, 867-3202   DD-MED-4
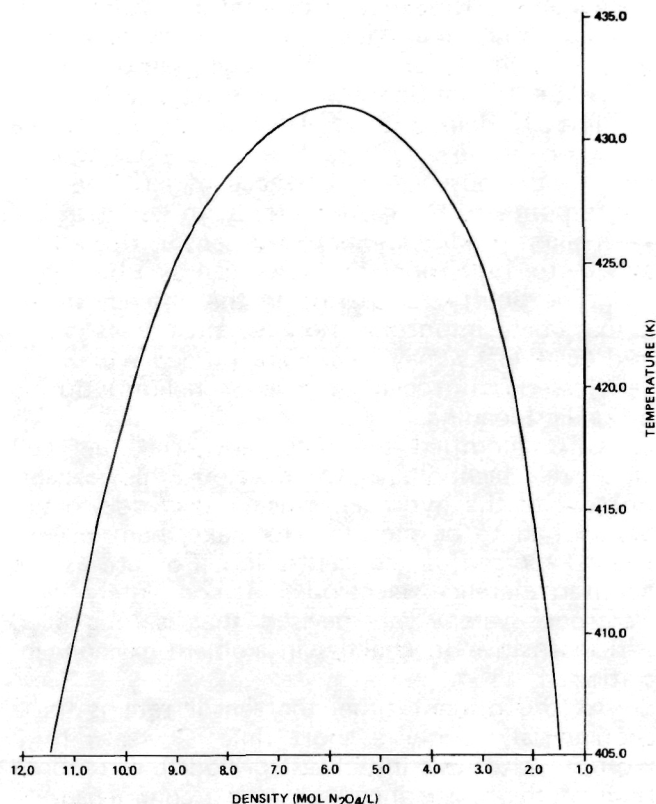
Density (moles N_2O_4/liter) vs. temperature near the critical point (saturation curve).

Hazardous Warning

Remote Sensing of Hydrazines

The objective of this research is to advance technology in the area of laser remote sensing for the detection of toxic and explosive concentrations of hydrazine vapor in the air. The Jet Propulsion Laboratory has been funded by the Kennedy Space Center to perform the initial research that will provide the parameters necessary to begin instrumentation design for remote sensing of hydrazines.

In the past 10 years, a number of laser remote sensing systems have been developed and used for the detection of pollutant gases such as methane and nitrogen dioxide. Recent work performed at the Aerospace Corporation and MIT Lincoln Laboratory indicates that hydrazine vapors have absorption features in the 9- to 12-micron spectral region, which makes laser remote sensing a feasible method for their detection.

The specific goals of the research are:
1. Measure the absorption spectra of the hydrazines in the 3- to 4- and 9- to 12-micron infrared spectral regions with a resolution of 0.1 to 0.02 cm^{-1}.
2. Study carbon dioxide (CO_2) laser and tunable diode laser (TDL) systems to determine design parameters of a system useful for low concentrations (less than 100 parts per billion) over short paths (approximately 10 m) and high concentrations (approximately 5 percent) of intermediate ranges (approximately 250 m).
3. Design one or more laser systems for remote sensing of the hydrazines.

A continuous-wave CO_2 laser system has been assembled for use in characterizing such a system using topographic targets. System performance is being characterized by aiming it at a concrete wall or a flame-sprayed aluminum target 75 m from the source. The path is 1 to 1.5 m above an asphalt road. The data collected will help to establish the system's limitations and identify areas that require additional development. This work will also be performed using a TDL system later in the program.

A gas cell is now being used to obtain absorption spectra with 1-cm^{-1} resolution for monomethylhydrazine and unsymmetrical dimethylhydrazine. These data, along with other spectral

data, will be used to determine the best wavelengths to use in the laser systems.

This initial research is planned to be completed in the second quarter of 1984. Plans are to continue the research in the laboratory and develop prototype instrumentation to measure gas concentrations in field environments. The instrumentation will also be used to verify system design, develop operational requirements, and finalize the system configuration.

P. M. Rogers, 867-3086　　　　　　DL-DED-32

Improved Parts per Million (PPM) and Percent Level Hydrogen Detection in Inert Atmospheres

Techniques typically used to measure concentrations of hydrogen and other combustible gases in air will not work in the absence of oxygen. Methods such as mass spectrometry and gas chromotography are too expensive for widespread use. A hydrogen leak detector is under development that will measure the concentration of hydrogen regardless of the presence or absence of oxygen. It uses a principle similar to that used for the Shuttle Orbiter's onboard fuel cells. There, hydrogen and oxygen are combined to generate electricity. In this sensor, an appropriate choice of electrode materials obviates the need for oxygen. An electric current is generated proportional to the amount of hydrogen present.
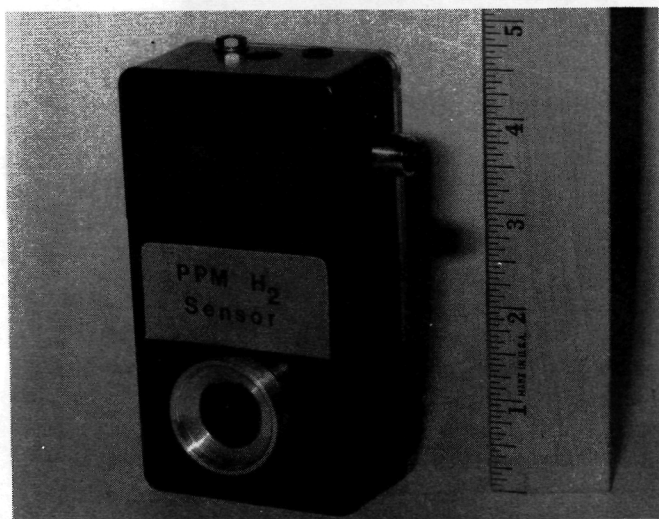
PPM H$_2$ sensor.

Catalyst Research Corporation (CRC), of Owings Mill, Maryland, recently developed a unique, accurate, and fast hydrogen sensor for use by NASA in the Space Shuttle program. The sensor linearly detects 0- to 4-percent hydrogen in a diffusion or flow system. It also operates equally well in the absence or presence of air. The sensor responds to the gas of interest in less than 2 s. With slight modifications to the sensor, 0- to 100- and 0- to 1,000-ppm hydrogen can also be detected. The ability to operate in the absence of air is extremely important, because most areas where hydrogen leaks may occur are purged with inert gas (gaseous nitrogen or gaseous helium) during propellant loading.

CRC modified the most advanced fuel cell electrode technology to develop this sensor. For use as the hydrogen sensing electrode, membranes had to be modified to make them insensitive to oxygen gas concentration. For use as the counter/reference electrode, a completely new electrode system was devised that is long lived and insensitive to changes in ambient gas concentration.

At the present time, the sensor retains these characteristics only a short time; 2 weeks to 2 months. After this initial test period, the response time of the sensor increases with a commensurate loss of sensitivity. Daily calibration is currently required, whereas monthly calibration or no calibration may be realized with improvements in the anode. Future plans include improvements in the cell lifetime and refinements of the mechanical package.

W. R. Helms, 867-4449　　　　　　DL-NED-3
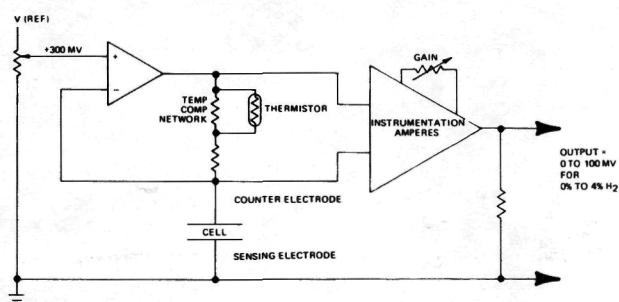
Schematic representation of electronic circuitry for gaseous hydrogen sensor.

Improved Low-Level Portable Survey Instrument for Hydrazine Detection

Hydrazine-based rocket fuels are used in large quantities on the Space Shuttle. They provide the

advantages of high energy, are storable at noncryogenic temperatures, and are hypergolic with nitrogen tetroxide (thus the engines are capable of multiple firings). However, they are highly toxic, suspected carcinogens and thus must be detected and monitored at extremely low levels. They are highly reactive on surfaces, making sampling with conventional instrumentation extremely difficult.

Kennedy Space Center has pioneered the development of reliable, low-level detectors for hydrazines and nitrogen tetroxide in both portable and rack-mounted versions. However, no instrument available was capable of measuring both existing and proposed allowable exposure limits. Kennedy Space Center has managed the development, by Energetics Science of Hawthorne, New York, of an improved portable instrument known as the toxic level vapor (TLV) hydrazine detector.
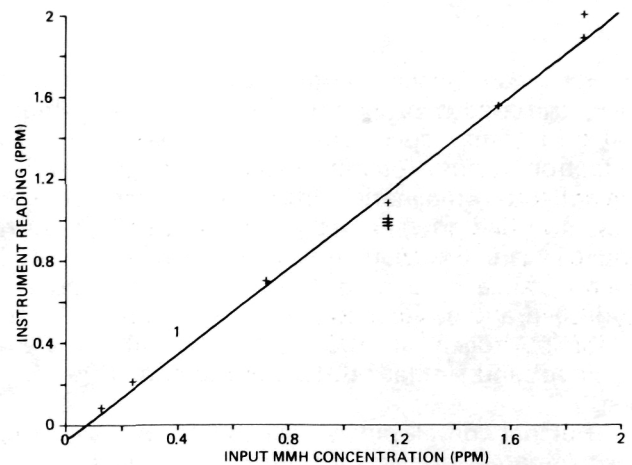
Energetics Science TLV detector.

TLV hydrazine detector.
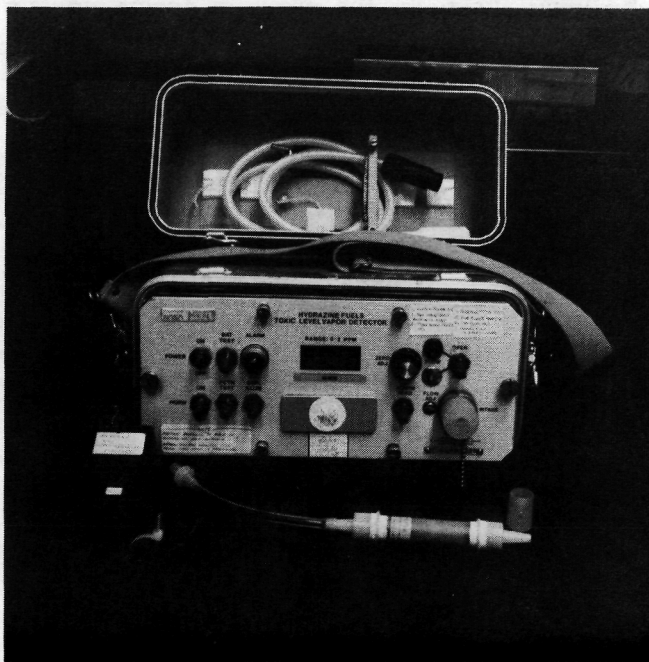
Block diagram of TLV detector.

The TLV detector is a portable, battery-powered, single-readout hypergolic fuel detector that is designed for the convenient onsite measurement of hydrazine in ambient air. The range of the instrument is 0 to 2 parts per million with a minimum resolution of 1 part per billion read on a liquid crystal diode display. The TLV detector continuously samples and analyzes ambient air by means of an electrochemical sensor. This sensor produces an electrical current that is directly proportional to the hydrazine or monomethylhydrazine concentration level detected in the sampled air. When the current produced by the sensor exceeds a preselected alarm level, audible and visual alarms are actuated.

Improvements over existing instruments are as follows:
1. Improved sensitivity and accuracy at low parts-per-billion detection levels
2. Longer sensor life (up to 1,200 h)
3. Excellent linearity
4. Minimum interference from ammonia, alcohol, humidity, etc.
5. Improved response and recovery time
6. Improved long-term calibration stability

W. R. Helms, 867-4449   DL-NED-3

11

Hazardous Gas Detection

Kennedy Space Center has, within the past year, initiated a program to develop an ultrahigh-reliability, mass-spectrometer-based hazardous gas detection system for multiprogram usage. A multiple-collector magnetic-sector mass spectrometer was modified to measure trace levels of hydrogen and oxygen. Excellent linearity was demonstrated over a range of 0 to 5,000 parts per million for hydrogen and oxygen. Signal-to-noise ratios of 3 to 1 for hydrogen at 100 parts per million were attained, and similar results were obtained for oxygen.

Further development and tests of the mass spectrometer are in process, and future plans include development of a sample delivery system and an extremely user-friendly computer control system.

In addition, an in-house test and evaluation program was conducted using a variety of hydrogen and oxygen sensors to develop a cost-effective backup subsystem for the Space Shuttle hazardous gas detection system.

Excellent performance was achieved with several trace-level oxygen detectors. Evaluation of hydrogen sensors will be completed early in 1984.

W. R. Helms, 867-4449   DL-NED-3
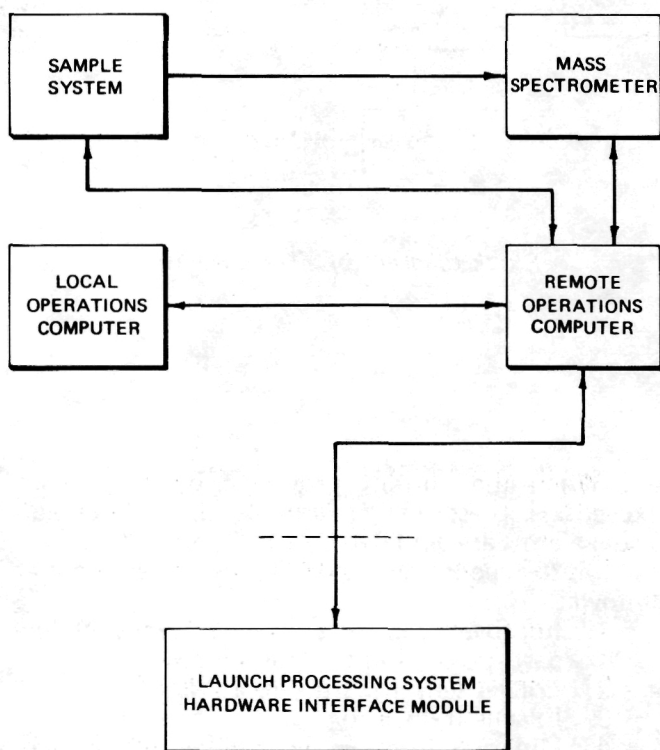
Ultrahigh reliability hazardous gas detection system block diagram.

Improved Leak-Check Methods of the Shuttle Main Propulsion Systems

The major hydrogen leak discovered in the Space Shuttle Orbiter aft fuselage during the flight-readiness firing of Challenger suggested that the conventional methods of performing system leak checks may not be adequate. The conventional leak-check methods used at the time consisted of using a soap-bubble solution, which when applied to a leaking joint would form bubbles, and a mass spectrometer, which would detect the presence of helium from a leak. These methods are used primarily to validate the integrity of separable or mechanical joints but not the structural integrity of the system. Also, when these techniques are used in the field, they can be influenced by environmental conditions such as helium background and wind. As such, the crack in engine no. 1's main combustion chamber structure was not detected following the initial flight-readiness firing. As a result, Kennedy Space Center personnel began developing an alternate leak-check method that could verify total system leakage. This method has been called the helium signature test.

The principle behind the helium signature test is that a leak in a closed compartment with a constant purge will stabilize at some level. If a system in the compartment is pressurized with a tracer gas, a leak in the system can be measured with an instrument.

When this test is performed, the Orbiter aft fuselage is closed with the exception of one vent door. The air purge into the aft fuselage is maintained at a constant flow rate. A mass spectrometer is set up to sample the purge effluent from the vent door. Helium is released into the aft fuselage at several known flow rates through test hoses to calibrate the mass spectrometer. Each system being tested is separately pressurized with helium, and the mass spectrometer is monitored for stabilized concentrations. The stabilized readings are compared with the calibration runs to determine the system leakage.

The helium signature test is currently used to verify integrity of the liquid hydrogen feed system, liquid oxygen feed system, gaseous hydrogen repressurization system, gaseous oxygen repressurization system, and each of the three main engine hot gas systems. The test has been very effective, as evidenced by the results found following the second Challenger flight-readiness firing. A 25-standard-in^3/min leak was detected in the hot gas system of engine no. 2, which was later isolated to a crack in the main combustion chamber augmented-spark-igniter hydrogen line. In another instance, during the Space Transportation System

flight no. 8 processing in the Orbiter Processing Facility, the test indicated a large leak in the liquid hydrogen system. This leak was found to be from a flange in one of the Space Shuttle main engine high-pressure-fuel turbopumps.

The helium signature test has been used with good success. Efforts are still underway to improve and perfect the technique. The test is now being used as a positive method to validate the integrity of the propellant systems both mechanically and structurally.

W. I. Wiley, 867-3197   SE-FSD-1

Structures and Mechanics

Heat Transfer in an Unsteady Turbulent Airflow Across a Section of the Shuttle External Tank (ET)

During the launch operation, the loading of liquid oxygen and hydrogen into the Shuttle's ET may cause ice to form on the ET surface. During lift-off, the ice could fall on the Orbiter and damage the Orbiter's thermal protection system. Because of the colder weather, the icing problem becomes more severe at the Western Launch Center at Vandenberg Air Force Base in California.

As a clean and cost-effective solution to this icing problem, Kennedy Space Center is proposing a wind-machine system. The system consists of several 100-hp fans mounted along the launch tower to circulate air around the ET. To verify this proposed solution, experimental and theoretical data on heat transfer in an unsteady, turbulent, high-Reynolds-number (order of 10^7) flow across the ET are required.

Since such data are not available elsewhere, a test program for determining the local heat transfer coefficients around the ET surface with either the ambient wind or the ambient wind and a fan has been carried out at Kennedy Space Center's Launch Equipment Test Facility. Heat
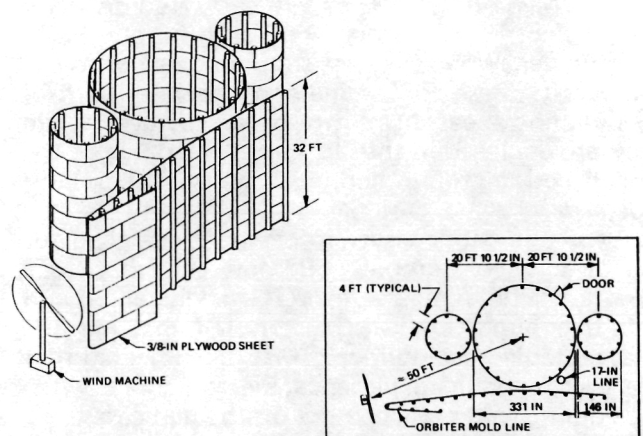
The second test configuration.

transfer data were recorded on two different test configurations. The first configuration consisted of a 32-ft section of the full-scale ET and solid rocket boosters. The second configuration included a 32-ft section of the full-scale ET, solid rocket boosters, and Orbiter wing. Detailed data analysis is in progress.

F. N. Lin, 867-4156   DD-MED-43
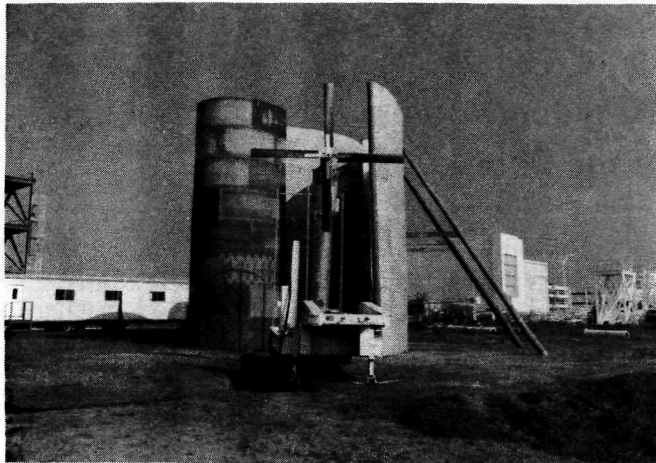
The test article and the wind machine for the second test configuration.

Application of Infrared Imaging to Convective Cooling Equipment Design

The International Solar Polar Mission and Galileo Mission in 1986 will carry radioisotope thermoelectric generators (RTG's) to supply spacecraft power. When they are supplying power to the spacecraft, these RTG's maintain thermal control by radiating excess heat into space. However, while they are enclosed in the Orbiter payload bay at the launch pad, a ground cooling system must be provided.

A water cooling system has been designed for use at Launch Complex 39; however, there is a period of time after the RTG is installed and before cooling water flow is started that permits unacceptable heat buildup. Analysis indicated that the RTG's would experience thermal shock when the cooling water reached the overheated cases.

To avoid such shock, a test project was conducted to evaluate the effectiveness of forced-air cooling. The test used an electrically heated simulator in conjunction with infrared imaging and a video recorder to study temperature patterns associated with different airflows. In this manner, design criteria were developed for a full-scale prototype forced-air cooling system.

W. K. Lackie, 867-2261   SE-PEO

Solid Rocket Booster (SRB) Towing-Simulation Computer Program

During the first several retrievals of the Space Shuttle SRB's from the Atlantic Ocean after splashdown, there was no equipment available for use by divers to seal the open nozzle. As the SRB's were towed back to port in a nearly horizontal attitude, they experienced a pitching motion fore and aft that would sometimes break the water seal at the nozzle, allowing seawater to replace entrapped air until the internal pressure stabilized. Although internal air pressure prevented any more water from entering, the large amount of water inside the casing, moving fore and aft, produced changes in attitude and motion of the SRB's. The problem was to analyze the motion of the SRB's when activated by the wave action of high seas and to determine the probability of their sinking. Previous model tests addressed this problem but were limited by scaling problems and the expense of repeated testing.

A solid rocket booster and retrieval vessel.

To analyze the motion of an SRB being towed in high seas, a computer model was constructed simulating the motion as a series of finite-difference steps in time. The model takes into account the towline force, wave and profile drag, added mass, buoyancy, and inertia. The motion of the internal water is modeled as a one-dimensional open-channel flow in a rotating and accelerating reference frame. The forcing function of the system is a regular train of trichoidal waves of given amplitude and wavelength.

Because of the motion of the internal water, the SRB no longer acts as a rigid body. This one-dimensional open-channel flow was modeled with an explicit finite-difference scheme, made difficult because it must model subcritical and supercritical flow with hydraulic jumps while maintaining exact continuity, since it is a closed system except for the nozzle flow. The equations then must be modified to account for sections of the channel that are completely full or empty. The filling and emptying through the nozzle must be approximated, whether it is flowing full or partially full; and the isothermal compression of the internal gas, which can be relieved to atmosphere when the nozzle is uncovered, must also be taken into account. The coefficients of added mass and drag could not be obtained quantitatively, so they were qualitatively adjusted to give results similar to model and ocean tests and actual towing of an SRB.

The program is written in FORTRAN and runs interactively with a limited plot routine. The results of this analysis were reported in the Kennedy Space Center document, "Solid Rocket Booster Towing Analysis Report," KSC-DD-657, December 1982.

R. E. Wickham, 867-7594   DD-MED-32

Centaur rolling Beam Umbilical System (RBUS)

An RBUS has been developed and is being added to the pad fixed service structure (FSS) for liquid hydrogen (LH_2) filling, draining, and venting of the Centaur in the Orbiter.

The RBUS consists of a wheel-mounted structure that supports an Orbiter umbilical plate at the Orbiter end and a facility umbilical plate on the RBUS. This assembly is mounted on a platform that has been added to the FSS. A suitable location on the FSS dictated a 6° incline up to the Centaur interface on the port side of the Orbiter. The rolling beam travels 11 m (36 ft) to the stowed position in the FSS. Power for acceleration of the
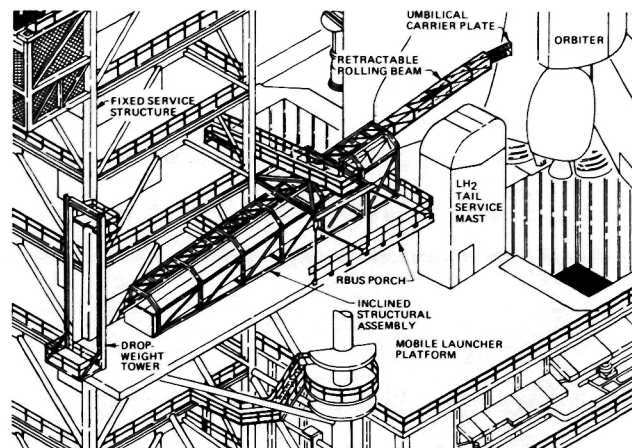
Rolling beam umbilical system.

rolling beam assembly is provided by a dropweight assembly. Upon initial motion of the carriage, the rolling beam simultaneously separates from the ground supply lines and from the vehicle. A linear disk brake similar to the brakes used on amusement park roller coasters decelerates the rolling beam to its stowed position.

The Orbiter umbilical assembly consists of carrier plate supporting links, an LH_2 fill-and-drain vacuum-jacketed flex line, an LH_2-vent vacuum-jacketed flex line, and purge lines. Carrier plate supporting links are equipped with ball joints to accommodate Orbiter motion.

The RBUS is mounted on an incline that sets the rolling beam on a 6° angle to interface with the Orbiter and facilitate stowage within the FSS. It also supports the static half of the ground separation plate for the LH_2 fill-and-drain lines and the gaseous hydrogen vent line. A pneumatically powered winch provides the means for lifting the rolling beam up the incline. A guide rail and rollers limit carriage sway.

The dropweight assembly contains the dropweight, dropweight lifting winch, and energy absorbers. The dropweight cable is routed through sheaves to the carriage attach point.

A latch mechanism holds the rolling beam in Orbiter-mated position on the incline prior to launch, with the dropweight applying static tension to the dropweight cable. Dropweight-actuated initiating-arm motion activates the release lanyards and transmits the accelerating force to the carriage. Primary release is by a pyrotechnic bolt. If the pyrotechnic bolt does not separate, an overcenter mechanism is released by a lanyard activated by Space Shuttle lift-off, which retracts the beam.

G. E. Reichle, 867-7585   DD-MED-31

Computer Sciences

Language for User Control and Communication (LUCC) for Space Station Operations

The early history of manned spacecraft software has largely been influenced by the hardware and software limitations of the data processing capabilities. The speed and memory limitations and the state-of-the-art were such that code was primarily generated in an assembly language. While this approach did yield the fastest, most efficient code, it was manpower intensive and difficult to understand and maintain. The result was that the life-cycle cost was quite high.

Advances in the state-of-the-art for data processing led to changes in the approach toward coding during Space Shuttle design and implementation of onboard and ground software. The limiting cost factor shifted from hardware to software. A successful approach to reduce software cost was to generate software in high order languages (HOL's). The resulting code was quite adequate for the job and was cost effective.

The traditional software approach prior to the Shuttle program led to a separation of functions between the operations personnel who were the software users and a separate software group that generated the programs to be used by the operations personnel. This separation of functions led to an interface that became quite formal, adding to the time required to prepare software and increasing the software life-cycle costs.

With the inclusion of software generated in a user-oriented HOL during the Shuttle era, the necessity for the formal interface between test engineers and system programmers was significantly reduced or, in most cases, eliminated. Automated procedures have become understandable, more automatic, and more easily changed, maintained, and validated. The necessity for a similar user-oriented, user-friendly communications tool (HOL) for Space Station operations is evident, considering the variety of tasks to be performed aboard the Space Station and the number of specialists required to make full use of the station's computing capabilities.

A study was performed in 1983 to determine if any existing HOL's (Government or industry) would meet the requirements for Space Station operations as they then existed. The languages investigated included Shuttle ground operations aerospace language (GOAL), Ada, systems test and operations language (STOL), abbreviated test language for avionics systems (ATLAS), HAL/s, and European test and operations language (ETOL). Of the HOL's reviewed, none would fit all the requirements. It was recommended that a HOL be provided that met the communications requirements (readable, writable, learnable, and reviewable by nonprogramming-oriented users) and technical requirements for the Space Station.

This language would be identified by the acronym LUCC, meaning language for user control and communication, and would initially include a subset of the HOL that came the closest to meeting the requirements (which turned out to be GOAL). It was also evident that the same functions must be performed for checkout and monitoring on the ground as would be performed on board. Therefore, considerable cost savings could be realized through the use of a common LUCC on board and on the ground.

A. Dorofee, 867-4430   DL-DED-22

Software Verification and Validation Tools for the Launch Processing System (LPS)

A study was initiated with the Harris Corporation, Melbourne, Florida, to identify software tools and techniques that would significantly enhance the quality of released Checkout, Control, and Monitor Subsystem (CCMS) operating system and support software. The projected mid-1980's launch rate of 20 to 40 Shuttle flights per year will not allow sufficient time to correct major software coding or design errors once the software has been released to user organizations. The quality of released CCMS system and support software must be improved by using whatever techniques (automated or procedural) may be available as state-of-the-art tools.

The study has thus far identified three existing tools that appear to fit requirements identified above. These tools are presently undergoing extensive analysis to ensure that they are indeed acceptable and useful at Kennedy Space Center (KSC):

1. COBOL Automated Verification System (CAVS). This tool was developed for the

Air Force by General Development Corporation.

2. FORTRAN Automated Verification System (FAVS). This tool was also developed for the Air Force by General Development Corporation.

3. Quality Measurement Tool Software (QMT). This tool was developed for the Air Force by General Electric Corporation.

All three tools run on both the Honeywell H6000 and Digital Equipment Corporation's VAX 11/780 computer systems, which are available at KSC. CAVS and FAVS will be evaluated in the KSC Shuttle LPS software design-to-release process. The tools will be used to see if automation of the software design-to-release process will significantly improve programmer productivity and result in programs that are more reliable and maintainable at less cost to the Government. For this evaluation, CAVS and FAVS will be used to provide:

1. Baseline sources and test data identification
2. Source code and test data revision control
3. Early identification of certain COBOL and FORTRAN anomalies
4. Accurate measurement of execution coverage for COBOL and FORTRAN modules
5. Keying test data sets to execution results

The third tool, QMT, will be evaluated as a monitor of software quality to see if it will significantly improve efficiency, reliability, correctness, etc. of the released LPS/CCMS software and result in programs that are less costly to the Government. For this evaluation, QMT will be used to:

1. Collect LPS/CCMS software quality data
2. Analyze or determine quality of the software
3. Provide a means of maintaining and improving quality in future releases

It is expected that this study will identify state-of-the-art software tools, techniques, and methods that will cost effectively reduce the number of released errors in the LPS/CCMS system and support software.

L. E. Morgan, 867-4430   DL-DED-22

Pisces - Launch Processing System (LPS) Computer Replacement

The Kennedy Space Center (KSC) currently uses Modcomp II/45 minicomputers as an integral part of the LPS, which is used for the processing, checkout, and launch of the Space Shuttle. There are 210 minicomputers that comprise the LPS at KSC, the first five having been procured in 1975. Since many of these minicomputers are approaching their 10-year life cycle, a replacement plan was needed to keep the LPS operational throughout the life of the Shuttle program. As the existing computer is no longer manufactured, a study was done to find viable replacement computers available off the shelf. The results of this study showed that no such replacement computer existed (without significant hardware, software, and microcode impacts) and that a custom design was required to minimize the operational impacts to the program and to improve system performance. A project was then started to design and develop a replacement computer, of which NASA would own the design and so could order it built competitively in the marketplace. The first prototype of this computer (Pisces) was delivered to KSC in May 1983. The detailed design and prototype fabrication were performed by Martin Marietta Corporation of Denver, Colorado.

The Pisces is a 16-b computer that is backward-compatible with the software (operating system), input/output bus interface (both central processing unit and option plane), and memory port devices of the original LPS processor. The Pisces has many additional features, including more memory, higher speed, and enhanced instruction set. The instruction set processor and the macroinstruction processor are implemented with large-scale-integration
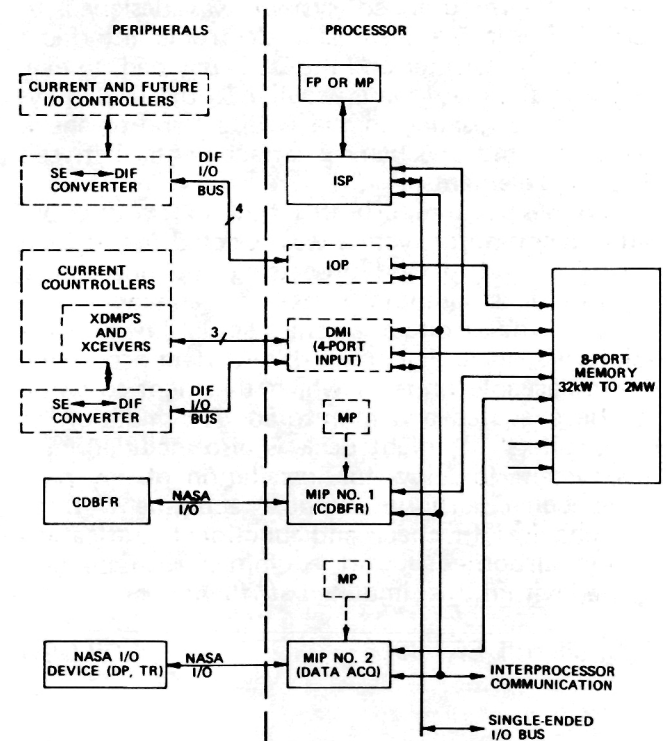
Basic Pisces processor.

bit-slice technology and solid-state random-access memory. The basic Pisces machine has one instruction set processor, one input/output processor, two macroinstruction processors, two 256-kilobyte memory boards, and one memory control board. The machine is capable of containing any combination of eight port devices (instruction set processor, macroinstruction processor, or input/output processor), four 1-megabyte memory boards, and one memory control board. Additional capability includes execution of the standard Modcomp II/45 instruction set plus 100 additional instructions custom tailored to the LPS operating system software, 8 kilobytes of local random-access memory on each processor, 16 memory address map files, interleaved 100-ns memory access with full error detection and single bit error correction, and 40-megabyte/s memory bandwidth.

R. D. Luken, 867-3086   DL-DED-3

Orbiter Functional Simulator (OFS)

The Orbiter functional simulator is a Department of Defense (DOD) project that provides a capability to verify payload-to-Orbiter interfaces. To prevent impacts to the Orbiters' launch schedule, this computerized system was designed to verify all the electrical and electronic interfaces between the Orbiter and the DOD payload, to execute the flight software peculiar to the DOD payload that is residing in the Orbiter, and to check many of the mechanical attachments between these two elements.

To best accomplish this function, a distributed minicomputer system was selected for its high reliability and ground processing and operability features. This computer system was enhanced with many of the Orbiters' avionics actual line-replaceable units, including the Orbiters' data processing line-replaceable units in which the flight software can be executed and monitored. A simulation of the Orbiters' aft flight deck is also included with this system to allow for installation of any payload-peculiar airborne support equipment. Both a mechanical fit check and functional verification of the airborne support equipment can be performed within this simulated aft flight deck.

E. G. Sherrill, 867-3645   CP-GSO

Artificial Intelligence Research

Shuttle ground operations have been identified as an expensive and time-consuming portion of the overall program. There are also the ever-present safety considerations involved. An approach to enhancement of ground operations is to effectively use artificial intelligence as a tool to help cut cost, save time, and improve safety in Kennedy Space Center (KSC) operations. Experts in the field of artificial intelligence recently completed an investigation of the potential for use of artificial intelligence in KSC operations. Two technical areas, fluid servicing and launch processing system software modifications, were selected for study. Both areas were determined to be amenable to use of expert systems. An additional project was formulated to build a demonstration model of an expert system using artificial intelligence to diagnose and recommend corrective action for problems in the Shuttle liquid oxygen servicing operation. The intent of the project is to prove the feasibility of the application of artificial intelligence technology to Shuttle checkout, monitoring, and control functions.

In addition, a 3-month investigation of artificial intelligence application to cargo processing was done using Space Transportation System payloads as models. The conclusion was that high payoff could be derived from several areas, two of the most promising being logistics and spares provisioning and planning and scheduling.

The potential for success has broadened the scope to include other areas of vital importance to KSC ground operations. Plans are nearing completion to extend an existing Space Transportation System logistics improvement study to include artificial intelligence technology and to build prototype demonstration expert system models for planning and scheduling and weather forecasting.

R. C. Delaune, 867-4935   SC-LPS-2

Communications

High-Speed Digital Multiplexer/Demultiplexer Development

With the installation of fiber-optic cables at Kennedy Space Center (KSC) and other areas, the ability to multiplex low data rates in order to make full use of the wide fiber-optic bandwidth becomes very important. Present-day multiplexers/demultiplexers are designed for specific data rates and do not allow the flexibility to change or add rates to meet new requirements. Existing KSC wideband cable plants are becoming obsolete and overloaded, and new fiber-optic cables are being installed to augment the transmission system. Many of KSC's transmission lines are of the low-data-rate variety and do not utilize the optical fibers' full bandwidth. Multiplexing techniques must be implemented to fully realize the fibers' potential.

A high-speed digital multiplexer/demultiplexer is being developed with the flexibility to handle a variety of data rates and incorporate new requirements. The multiplexer/demultiplexer will be a modular system capable of handling 16 different input signals of up to 2 Mb/s each. The multiplexer will time-domain multiplex the input signals and generate a composite 50-Mb/s output signal for transmission over fiber-optic cable. The demultiplexer will incorporate a high-speed bit synchronizer for locking on to the 50-Mb/s data signal and separating the 16 data channels for transmission to the users. The output modules will monitor the output data and adjust the output frequency for smooth transmission of all data. The output frequency may vary up to ±2 percent of the data rate.

Standard input and output modules will be used to interface the multiplexer/demultiplexer with the signal to be transmitted. Special-purpose modules could be designed to meet special interface requirements. The concept of multiplexing data signals into a high-speed data link should provide more efficient use and flexibility of the KSC optical-fiber plant.

A prototype 50-Mb/s multiplexer/demultiplexer is currently being developed under contract by Martin Marietta Corporation for NASA. The multiplexer will consist of 16 input modules and 1 multiplexer module. The demultiplexer will consist of a bit synchronizing module, a demultiplexer module, and 16 output modules. Design of the multiplexer/demultiplexer will be completed in November 1983, with a working prototype by March 1984. At that time, the unit will be tested in the KSC fiber-optics laboratory, and refinements will be incorporated before production units are ordered.

T. L. Herring, 867-3842   DL-DED-32

Fiber-Optic Transmission System

Kennedy Space Center has implemented a fiber-optic transmission system to support Spacelab payload ground checkout. The current system utilizes approximately 12.5 km of 10-fiber cable to connect various facilities required for checkout of the Spacelab unit and its payloads. The system operates at data rates up to 50 Mb/s on multimode, 50-μm-core optical fibers. The fiber is of a dual-window design, allowing operation at both 850 and 1,300 nm, although the current terminal hardware operates at 850 nm only.

The interbuilding system, in conjunction with the intrabuilding system internal to the Operation and Checkout Building, allows complete ground checkout of the Spacelab through its various stages of configuration, from an empty shell, to a test stand, to a flight-ready payload in the Orbiter payload bay.

In addition to the 50-Mb/s Spacelab digital data, this system also provides for the transmission of 16-kb/s to 2-Mb/s digital data, 30-Hz to 4.5-MHz analog and National-Television-System-Committee video. The low bit rate and analog
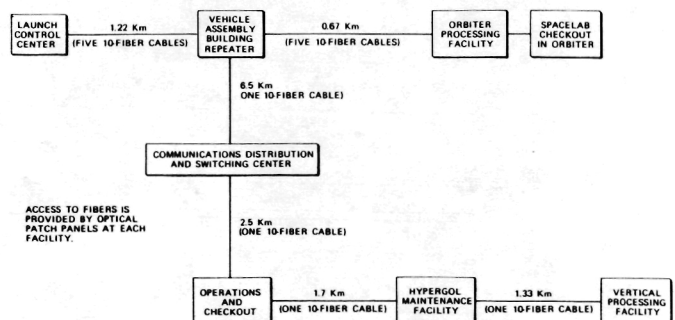
Interbuilding system.
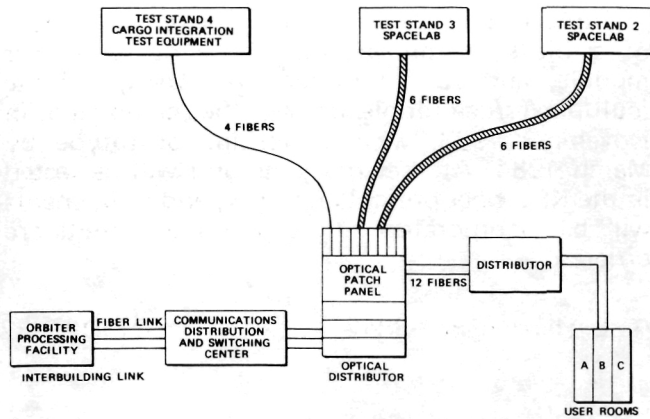
Intrabuilding system.

signals are transmitted using a frequency modulation technique that allows the use of digital optical transmitters and receivers.

These systems are the result of application research efforts conducted at Kennedy Space Center in the area of optical-fiber communication since 1975. Research efforts continue in the areas of terminal equipment development, single-mode fiber transmission, fiber-optic sensors, and space qualification and repair of fiber optics in space applications.

M. Padgett, 867-3367   ·   DL-NED-12A

Meteorology

Mesoscale Atmospheric Simulation System (MASS) - Kennedy Space Center (KSC) Weather Prediction Modeling

Improved weather prediction capability is necessary for the preparation, checkout, and launch of space vehicles at KSC. For this reason, KSC, in cooperation with Langley Research Center and Goddard Space Flight Center, has been developing an advanced computer weather model to improve the forecasting of thunderstorms and other critical weather phenomena at KSC. The model is called the MASS.

The MASS model is unique, because it predicts weather events, such as thunderstorm complexes, on small time and space scales. The computer weather models presently in operational use by weather forecasters, such as the limited fine mesh (LFM) model, have coarser spatial resolution and cannot depict events such as thunderstorm complexes. For example, the MASS convective precipitation forecast shows detail in the precipitation pattern very much like that actually seen by the radar and detail very much like the cloud pattern seen from the geosynchronous operational environmental satellite (GOES).
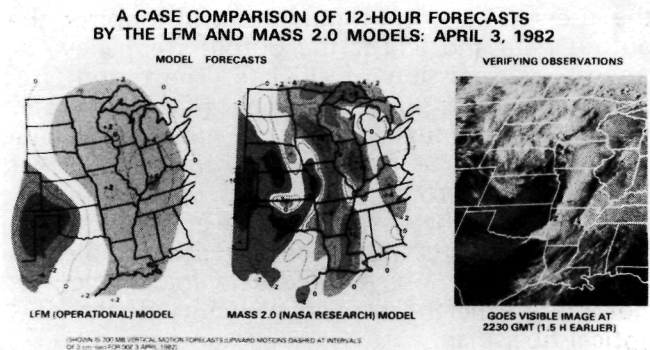
A case comparison of 12-hour forecasts by the LFM and MASS 2.0 models: April 3, 1982.

NSW RADAR SUMMARIES

MASS 14km
NESTED-GRID CONVECTIVE
PRECIPITATION (in.)
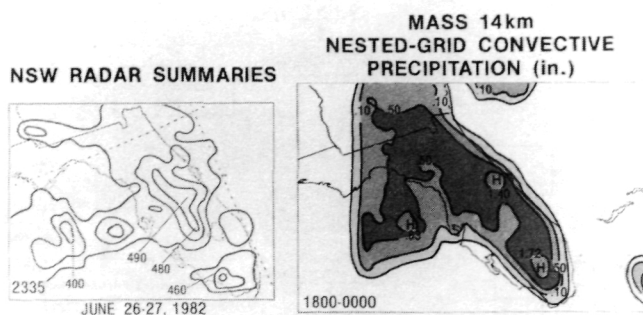
Comparison of National Weather Service radar summary to MASS predicted convective precipitation pattern.

GOES SATELLITE

15-HOUR CONVECTIVE
PRECIPITATION FORECAST (in.)
VALID FOR THE PERIOD FROM 1200 GMT
3 JUNE TO 0300 GMT4 JUNE, 1980
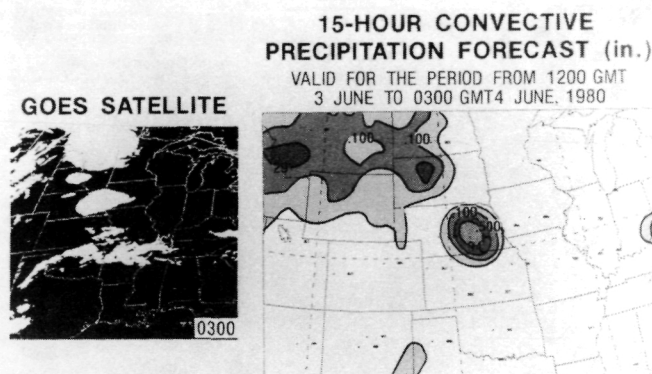
Comparison of GOES image to the MASS predicted convective precipitation pattern.

While the results so far have been promising, the value of the MASS model is still to be proven. This coming year, the MASS model will undergo an intensive evaluation. As many as 12 test simulations are to be run and evaluated by NASA. An operational test and evaluation is to be conducted at KSC.

R. P. Wesenberg, 867-4438   DL-NED-3l

Lightning Protection Using Flux-Cancellation Techniques

When lightning occurs in the vicinity of areas where explosives and propellants are handled, all operations stop and personnel are evacuated, causing problems with schedules and increasing the cost of operations. In some of these areas, vital equipment is in place and cannot be moved. Loss of this equipment could cripple some programs. For these reasons, there is a critical need for advanced lightning-protection techniques for areas at Kennedy Space Center where hazardous materials are handled.

A new method for providing this protection is under development at Kennedy Space Center. The method makes use of the fact that if lightning current can be conducted away from a building in a geometrically symmetric fashion, the magnetic fields generated by those currents tend to cancel one another. Combined with other techniques, the result is a significant attenuation of the induced lightning danger to persons working with explosives and propellants. This coming year, the goal is to prove the new method, to develop techniques to quantify the level of protection needed and achieved, and to apply the method to a hazardous-operations area.

R. P. Wesenberg, 867-4438   DL-NED-31

Technology Applications

Application of Kennedy Space Center (KSC) System Assurance Analysis (SAA) Methodology to Nuclear Power Plant Designs

As part of the investigations following the Three Mile Island incident in 1979, NASA was requested to support the Nuclear Regulatory Commission (NRC) with their knowledge in the field of safety and reliability. This request initiated a series of proposals that resulted in a NASA/NRC interagency agreement.

Under this agreement, KSC is to evaluate their SAA methodology for its applicability to nuclear power plant designs. The SAA has contributed significantly to the safety record of the space program. It has been used to analyze a wide variety of simple and complex ground systems, both electrical and mechanical, and has been very successful in identifying critical single failure points (CSFP's) and hazards in space program ground support equipment. Early identification of these weaknesses has permitted their elimination or prevention by design or control procedures prior to operations.

North Carolina's Duke Power Company expressed an interest in the study and proposed its nuclear power facility at Catawba for the basis of the study. In joint meetings of KSC and Duke Power Company personnel, two Catawba safety-related systems, the containment spray system and the residual heat removal system, were selected for detailed analysis.

The KSC SAA methodology demonstrates the simplicity of integration of the reliability and safety techniques used to accomplish the SAA. The goal of a reliability analysis is the prevention of loss of system and system function degradation. The goal of a safety analysis is the prevention of loss of life and system safety degradation. The SAA is a method of analyzing the system design to meet both of these goals. The results of the SAA not only provide the designer with identification of CSFP's and hazardous conditions, which the designer attempts to eliminate, but also provide
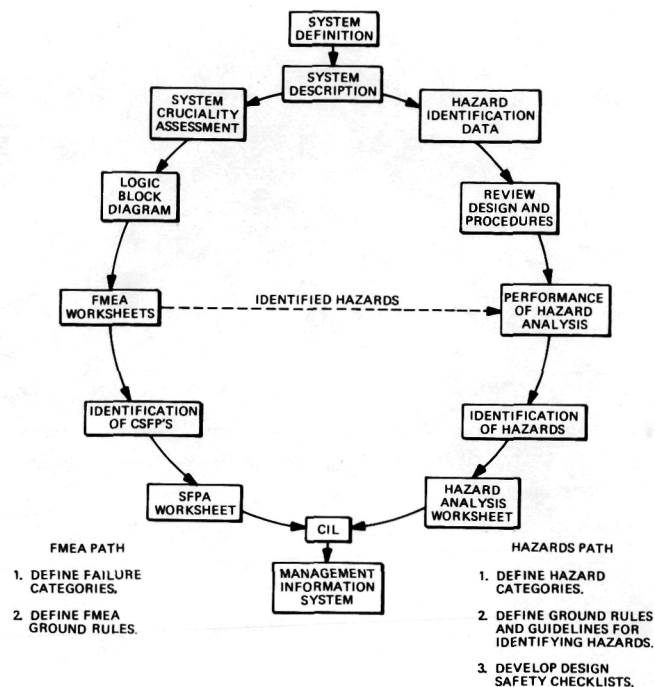
System assurance analysis.
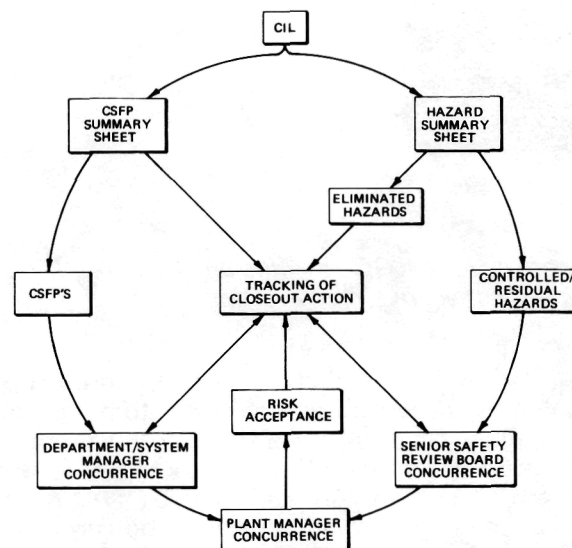
Reliability and safety management information system.

management with visibility of residual hardware problems and the risk those problems represent. The SAA also provides data for use in identifying mandatory inspections and test points for operations and maintenance documents.

The seven basic elements of the SAA are: (1) system definition, (2) failure mode and effects analysis (FMEA), (3) criticality assessment, (4) critical single failure point analysis (SFPA), (5) hazard analysis, (6) critical items list (CIL), and (7) management information and tracking system.

The technical approach to the study was planned in two phases. The main objective of Phase I was to determine the feasibility of applying the SAA to nuclear power plant designs. Phase I was to conduct a preliminary FMEA and SFPA of the selected systems. It was also to include an outline of the approach and techniques to be used in the performance of the hazard analysis of Phase II. Phase II is to include refinement and finalization of the FMEA and SFPA, conduct the hazard analysis, and prepare guidelines for conducting the SAA on nuclear power plant systems.

The Phase I portion of the study has been completed. The conclusions from Phase I indicate that the KSC methodology is readily adaptable to nuclear power plant designs. The universal application of this methodology is seen in its practical use of existing and familiar safety and reliability techniques that are controlled by a unique and informative management system. This methodology could satisfy the needs of the nuclear power industry for some type of deterministic method of demonstrating safety and reliability confidence in nuclear power systems designs, as well as supplement and be compatible with a probabilistic risk analysis.

The analysis used in this methodology is applicable to both new and existing systems' designs. The methodology doesn't end when the design is finished and the systems are operational. The analysis continues to be an important evaluation tool as long as the system is operational.

While the feasibility of the KSC methodology has been demonstrated, some practical considerations need further exploration. First, for this methodology to be most useful and attractive to the nuclear power industry, it should be an integral part of the design and/or licensing process, not just an additional requirement. Second, the present direction taken by the NRC is to establish safety goals with numerical guidelines without any deterministic requirements. The KSC methodology does consider the probability of failure in the SFPA, but this consideration is only one of the many items examined to determine if a single failure point is an acceptable risk. Many other factors are also identified and/or verified through a management information and tracking system, such as: design safety margins, qualification testing, mandatory inspections, training and certification requirements, operating procedures, and other related items. The SAA methodology is basically a qualitative technique, but it can provide the basic inputs to the probabilistic risk assessment if additional emphasis is provided in preparation of the logic block diagram (or fault tree). KSC is presently negotiating with the NRC for the continuation of Phase II of the study.

D. W. Page, 867-3402   DL-NED-21

Demonstration to Simulate Nuclear Power Plant Operation Using Kennedy Space Center (KSC) Software Control Concepts

The purpose of this demonstration is to simulate the operation of a nuclear power plant by utilizing the software experiences and techniques of automated process control developed at KSC for performing Shuttle checkout and launch activities. The demonstration shows how the KSC software methodology might assist the nuclear power industry in developing automated process control while maintaining safe power plant operating conditions. The computer is used to automatically perform repetitious daily operations while providing a method of positive safe control of anomalous and unexpected situations. It also provides an updated schematic picture of the status of the reactor and its support systems. The computer samples operational data and presents the information to the schematic picture in a simplified manner.

This demonstration presents a simulation of both normal and anomalous situations. It shows how the methodology:

1. Permits the operator to take direct, manual control over individual components
2. Analyzes data to present alternative courses of action for functional operations
3. Automatically reacts to dangerous or potentially hazardous conditions

D. W. Page, 867-3402   DL-NED-21

Multispectral Analysis of Nuclear Magnetic Resonance (NMR) Imagery

Kennedy Space Center, Washington University, and the University of Florida are working jointly on pioneering research with NMR imagery. NMR is a new medical diagnostic tool that has great potential for solving medical problems that currently have no solution. Kennedy Space Center and University of Florida engineers are applying NASA multispectral image processing technology for the purpose of analyzing NMR medical data obtained from Washington University's Mallinckrodt Institute of Radiology physicians.

Private industry, including Siemens Co., General Electric, and McDonnell Douglas, are very

much interested in this activity and are monitoring the progress for applicability to their commercial NMR systems.

NMR imagery includes sets of data for proton density and relaxation times that are in registration for multiple sections through an organ or body region of interest. An analogy exists between satellite imagery and simultaneous sets of NMR images at the same anatomic level with different contrasts (e.g., proton density, T_1, and T_2).

Satellite images, such as those from the LAND-SAT, are available in sets where the elements of each set are individual frames of visible light, near infrared, far infrared, and others. Advanced image processing system for the analysis of satellite data have been constructed by NASA and others.

Simultaneous sets of NMR data (proton density, T_1, and T_2) have been converted into a format that is compatible with a satellite image processing system (General Electric Image 100) owned by NASA and operated by the University of Florida.

The analysis of these NMR data with the image processing system allows summarizing of the contrasts present in each individual NMR section into a single color image that contains the important contrast information from each of the elements. In this manner, the image processing system can form a single image containing the important information from three or more separate images of the same section. For example, at a given slice location in the brain, a single color image (with near-true color) can be constructed by combining the proton density, T_1, and T_2 images at the same anatomic location. A computer-generated multispectral classification of the important features can also be constructed. For example,
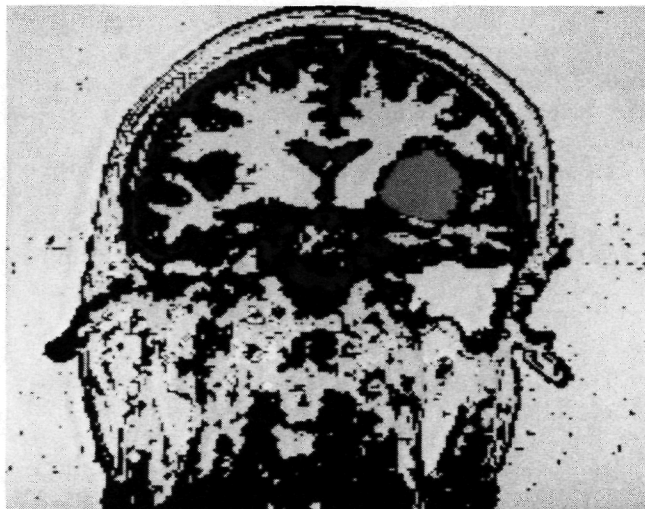
Computer-generated multispectral classification of important features of the brain.

a green signature area is a hematoma, a light blue area is white matter, and a dark blue area is cerebral-spinal fluid.

R. L. Butterfield, 867-3017   PT-TPO

Single image containing important information from three or more separate images of the same section of the brain.

Evaluation of a Photovoltaic-(PV)-Powered Water Electrolyzer

A prototype water electrolyzer powered by a solar PV array was operated for 3 months at the Florida Solar Energy Center to identify and study technical and economic factors associated with the production of hydrogen for energy storage purposes. The use of electrolytically produced hydrogen to store solar energy is an interesting alternative to battery storage of solar electricity. In addition, stored energy is in a form that can be used readily in combustion engines or burners as well as in fuel cells.

The primary components of the test setup were a 15-cell potassium hydroxide electrolyzer manufactured by Teledyne Energy Systems and a PV array consisting of 50 Solec model 3136 modules covering a total area of 200 m^2. The electrolyzer and PV array were specifically selected to provide an optimum voltage and current match to obtain maximum power output for anticipated PV insolation levels. Data recorded during the test period

System schematic for evaluating the Teledyne RES/HG electrolyzer.

included PV voltage and current, electrolyzer hydrogen output flow rate, insolation, and ambient temperature.

At maximum illumination, the electrolyzer and PV array operated at about 28 V direct current and 19.5 A (546 W). This current produced 1 liter/min of oxygen and 2 liters/min of hydrogen.

This project represents the beginning of the development of technology required for residential energy storage using solar-energy-produced hydrogen. Advances in many technical areas are required to make this system practical, but all necessary advances seem achievable with some moderate amount of effort. The biggest factor is the cost of solar cells. This cost would need to be reduced to about one-tenth of what it presently is. When this cost reduction does occur, production with a PV-powered electrolyzer, storage of energy, and use of hydrogen within a private residence could become very practical.

G. L. Reuterskiold, 867-3324   DD-MED-43

Prototype Cellulose Conversion System

Conversion of cellulosic material into mono-sugars by breaking the link of the large molecular chains with the aid of a strong acid has long been the goal of research. The products resulting from this conversion and fermentation techniques could be used as a low-cost energy food for animal and liquid-fuel production. Agricultural fibers are mostly wasted at present but could be used in this manner in the food chain to serve the ever-increasing world population.

In the University of Florida patented process, sulfur trioxide is used to intimately disperse formed sulfuric acid throughout the solid fiber mass, to subsequently decrystallize the crystalline alpha cellulose into the amorphous form, which later can be hydrolyzed with the acid as catalyst in a continuous process. As a joint project between NASA and the University of Florida, a laboratory-sized pilot plant has been designed and built to define continuous processing parameters for the innovative method for which a processing patent with 21 claims has been allowed. The investigations with the jointly produced laboratory-sized facility should lead to a permanent design for a commercial pilot plant. This plant will produce fuel ethanol from agricultural (waste) fibers, concentrated xylose as a substitute for black-strap molasses as feed for ruminants, and precipitated lignin for use as fuel to drive the entire processing system.

The laboratory-sized plant has been assembled at the university's Institute for Food and Agricultural Sciences. Only the upper stream in the schematic flow diagram was constructed under the joint project agreement.

S. S. DiPasquale, 867-3335   DD-MED-43

A) Air inlet regulator and heater
B) Fiber admission rotary valve
C) Metering valve for SO_3 intake
D) Reaction tubes for SO_3 and fiber particles
E) Centrifugal air mover and cyclone classifier
F) Abrasion system
G) Hammermill
H) Hydrolyzing unit input of saturated steam and treated fiber; output of lignin and liquid containing dextrose and xylose
I) Lignin and residual fiber system for energy production
J) Combined dextrose and xylose stream
K) pH correction with calcium to about 4.0
L) Fermentation of combined dextrose and xylose stream
M) Concentration of combined stream of ethanol and xylose fermentation by yeast

Schematic flow diagram for laboratory pilot plant.

25

Feasibility Analysis of a High-Efficiency Dehumidifier Air-Conditioner Using Heat Pipes

The idea of using heat pipes in between the supply-air duct and return-air duct in conventional air-conditioning units promises to be a cost-effective way to increase the latent heat-removal capacity. This design feature is particularly attractive for subtropical climates where humidity control is essential to both industrial processes and human comfort.
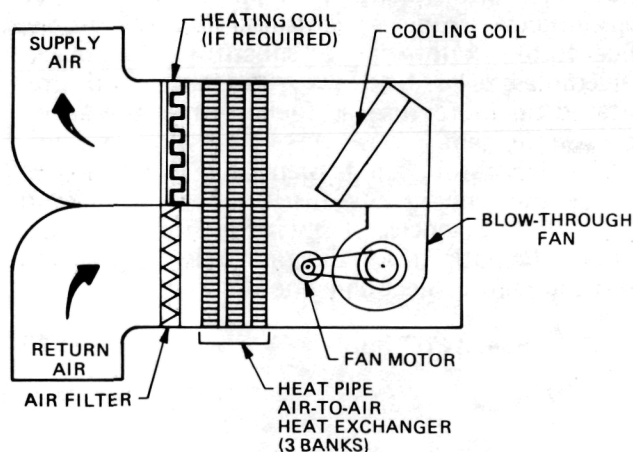

Schematic of an air-handling unit with three banks of heat pipe air-to-air heat exchange.

The unique aspect of the use of heat pipes is that it allows efficient removal of sensible heat from the air approaching the evaporator and transfers it to the air that has passed through the evaporator, providing reheat. In essence, the heat pipes reduce the sensible load on the evaporator, drop the off-coil temperature, and significantly increase moisture removal. The goal of the project is to demonstrate a latent heat fraction of approximately 60 percent, as opposed to 20 to 30 percent typical of conventional units.

The principal contractor is the Florida Solar Energy Center. Parallel studies are in progress with Research Triangle Institute to determine the extent of commercial application of the general technology of heat pipes and with Econ, Incorporated, to determine commercial market potential of this particular application.

R. C. Koning, 867-3688   DD-FED-33

Safety Engineering

Demonstration of the Light-Activated Reduction of Chemicals (LARC) Process for the Decomposition of Polychlorinated Biphenyl (PCB)

Kennedy Space Center (KSC) has recently entered into a shared-cost contract with Atlantic Research Corporation of Alexandria, Virginia, in a joint effort to extend LARC technology for decontamination of hazardous wastes from laboratory status to a full-scale field demonstration. This project presents a unique approach to dealing with a problem having substantial economic and environmental impact at KSC. Due to research activities in rocket propellants, Atlantic Research Corporation has had to pursue the disposal of resulting hazardous wastes, including certain halogenated compounds. PCB is one compound of this family, and laboratory work to date has established its susceptibility to photolytic decomposition. The LARC process is an innovative and noncomplex means of achieving photolytic decomposition, which lends itself to adaptation for processing PCB-contaminated material.
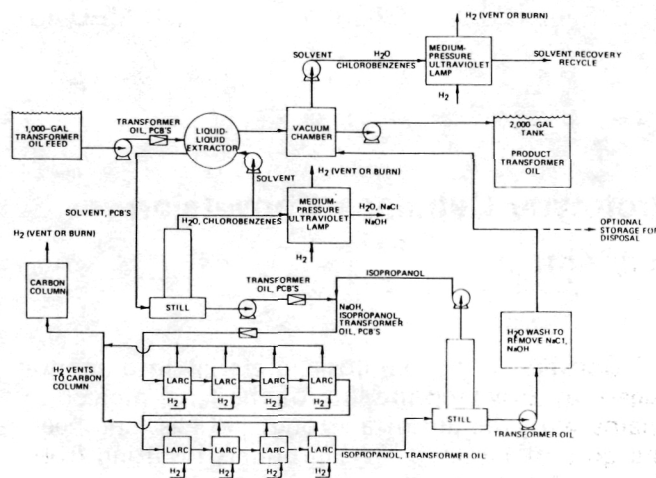
Preliminary LARC flow diagram.

In a building-block arrangement of basically simple elements, this project will demonstrate the technical and economic viability of processing PCB-contaminated material (contaminated transformer oil in the KSC case) essentially in place, through a unique photolytic decomposition device. High-temperature incineration is avoided and exotic reagents are not required. Process residuals would be significantly reduced in volume, nonhazardous, and suitable for conventional landfilling. Reclaimed transformer oil would be reused. Potentially hazardous transportation of contaminated materials to remote locations for incineration or burial would be substantially curtailed.

The LARC process was originally developed for the destruction of Kepone, a halogenated compound. Ultraviolet light (1,850- to 4,000-Å range), used to sensitize carbon-chlorine bonds (as are found in PCB's), is combined with hydrogen sparging and a chemical stripping reaction to effect dehalogenation of the PCB. Some sodium hydroxide added to the reaction allows the free chlorine to drop out as sodium chloride.

KSC's PCB disposal problems are not uncommon, being shared by other NASA centers and other agencies of the United States Government. The nation can benefit from the technology attainable through the successful demonstration of this novel approach to PCB decontamination.

J. V. King, 867-2196   DD-FED-21

Prototyping a Personnel Emergency Egress Vehicle

A development program has been initiated that will allow preparation of specifications to provide a number of personnel rescue vehicles for use at Kennedy Space Center, Vandenberg Air Force Base, and alternate landing sites. The Shuttle launch pads contain many hazardous fluids. Each of these fluids has one or more adverse characteristics such as being toxic, flammable, explosive, corrosive, carcinogenic, asphyxiating, or extremely cold. If an incident occurred involving a sizeable spill of one or more of these hazardous fluids, it might be necessary to restrict vehicles, including ambulances and self-contained-atmospheric-protective-ensemble-(SCAPE) vans, from the pad area. Removal of an injured worker, therefore, becomes a major problem, since the person may have to be carried for up to 0.6 mi. If toxic vapors are present, the litter bearers and the patient must be protected by breathing aparatus and protective cloth-

ing. A similar scenario exists if an Orbiter were to overrun the landing strip and medical evacuation for its occupants were required.

These hazardous operations preclude the use of batteries or internal combustion engines as power trains; the vehicle must be nonsparking and have no heat source. A self-propelled personnel carrier featuring a pressurized hydraulic power train that could be operated by a single rescuer would fill the need.

Currently, a hydraulic breadboard and a test bed are under construction at Kennedy Space Center. Testing and evaluation will be conducted on site to evaluate the vehicle's feasibility and identify design and operational requirements. Simulation of pad and runway recovery emergencies will be conducted to permit fire and rescue personnel to make evaluations and recommendations. User participation will be stressed. The current schedule projects completion of the testing program by January 1984.

F. E. Lundy, Jr., 867-2759   DD-MED-42
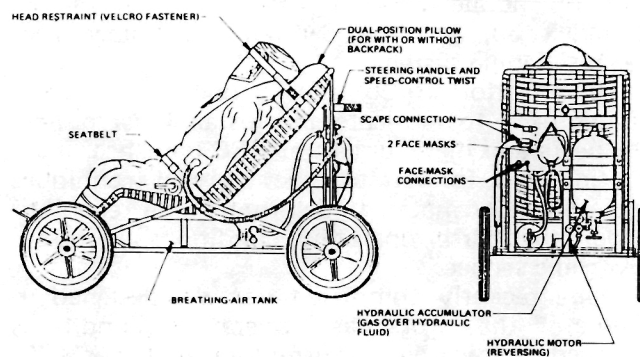
Personnel emergency mobility module.

Materials Analysis

Invar Weld Testing

Invar is an iron-nickel alloy that has properties favorable for use in vacuum-jacketed cryogenic fluid piping. At ambient and cryogenic temperatures, this alloy exhibits high yield strength, excellent ductility, and minimal thermal expansion and contraction effects. Invar is used in every liquid-oxygen and liquid-hydrogen propellant loading system currently operating at Kennedy Space Center (KSC), in pipe sizes ranging in diameter from 1 to 10 in. Invar will also find extensive use in future liquid-oxygen and liquid-hydrogen propellant systems on mobile launcher platform no. 3, Launch Complex 39, and the Centaur upper-stage propellant loading system.
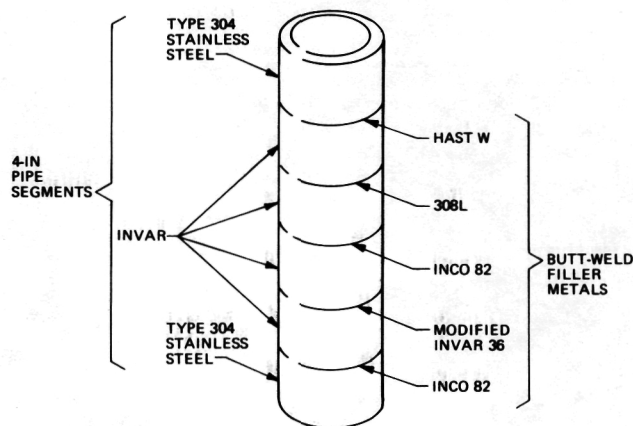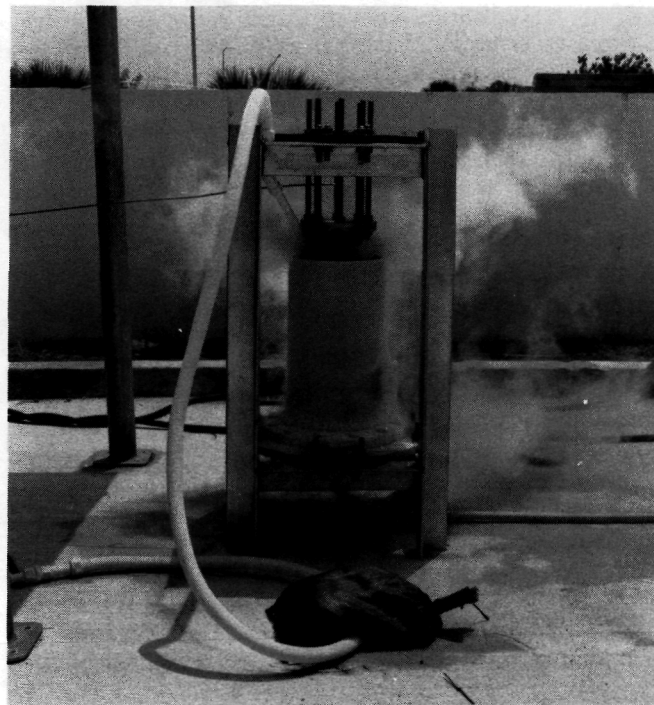
In an effort to continually upgrade the techniques used to fabricate and install Invar piping, engineers and metallurgists at KSC have been conducting tests for various types of weld techniques and weld filler metals to determine their reliability under the harsh operating conditions found in cryogenic service.

One recently completed test was designed to simulate the worst-case operating conditions imposed on Invar piping currently installed at KSC. Two identical test specimens of 4-in-diameter pipe were fabricated using a combination of 4-in pipe

Liquid nitrogen bath test fixture.

segments and various butt-weld filler metals. Each weld was X-rayed and the locations of certain weld deficiencies were recorded prior to testing.

Each specimen was bolted into a test fixture and pressurized internally with helium gas. The specimens were then alternately bathed in liquid nitrogen (-320°F) and water to simulate the operational chilldown and warmup cycle of cryogenic propellant systems. This cycle was repeated 100 times, subjecting the test specimen welds to low-cycle fatigue typically experienced by cryogenic systems at KSC. Peak stresses caused by thermal contraction and internal pressure are representative of those found under the most severe operating conditions at KSC.

Following the test, each specimen weld was X-rayed to provide a comparative view of weld deficiencies before and after testing. Further analyses of the test specimens were performed by metallurgical examination to evaluate the weld techniques and filler metals and to investigate why one weld failed the test.

S. W. Walker, 867-7969   DD-MED-43

Invar weld test specimen.

Protective Coating Systems for Carbon Steel, Aluminum Alloys, and Stainless Steel

In 1970, a test program was undertaken by the Materials Testing Branch at Kennedy Space Center (KSC) to evaluate organic and inorganic coatings for protection of carbon steel. Test panels were coated and exposed at the beach corrosion-test site and evaluated after 18 months, 3 years, 5 years, and 10 years. It was determined before the 18-month evaluation that the organic coatings performed poorly and the inorganic coatings exhibited excellent corrosion protection; many are still performing well today.
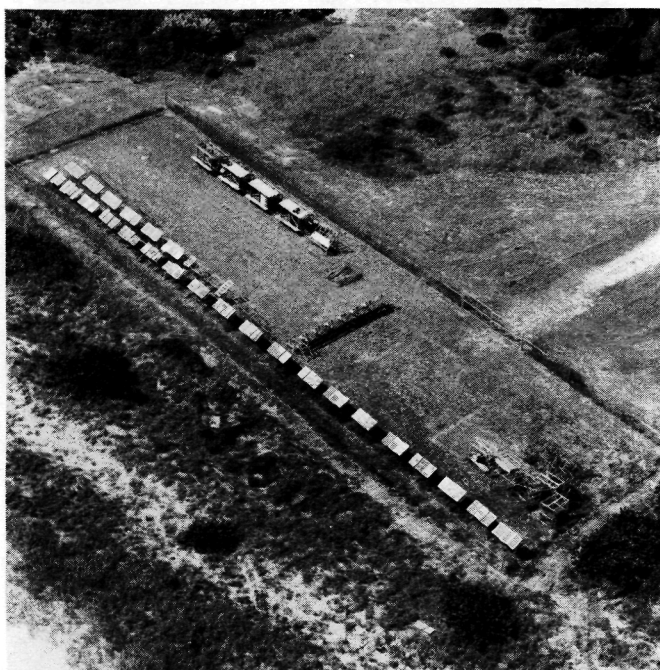
Aerial view of beach corrosion site, facing due east 100 ft from the mean high tide line of the Atlantic Ocean.

By 1981, an additional hazard had been introduced into the environment of KSC launch structures and ground support equipment. This hazard is the products of the solid-rocket-booster exhaust, which includes small particles of alumina (Al_2O_3) with hydrochloric acid (HCl) adsorbed on the surface of those particles. Wherever this cloud of particles settles, the zinc-coated structures are being damaged, even though a pressure washdown is carried out as soon as is practical.

It was evident that acid-resistant topcoats were needed in potential exposure areas. Also, by 1981, advances in paint technology had produced new coating systems that claimed better corrosion protection and easier application. With this in mind, a study was initiated in 1982 to evaluate application characteristics, repair techniques, and field performance of a variety of protective coatings, resistant to a marine/acid environment for use on carbon steel, aluminum alloys, and stainless steel.

In order to accomplish this program, 849 test panels were placed at the beach corrosion-test site during the months of July and August 1982. The 849 test panels encompassed single-component inorganic zinc coatings, two-component inorganic zinc coatings, epoxy tie-coat/urethane topcoat systems, alternative topcoat systems, and coating systems for stainless steel and aluminum. Also included were the repair panels used to evaluate many of the coatings mentioned above for their ability to be repaired by different surface preparation and application techniques.

The program consisted of three different types of test panels:
1. Panels exposed to normal conditions
2. Panels exposed to an Al_2O_3/HCl slurry
3. Panels exposed to an Al_2O_3/HCl slurry and rinsed off 1 h later

Evaluations of the panels for corrosion and acid resistance were performed at 3 months and 1 year and will be performed again at the end of the 18-month exposure period.

Although final conclusions on a coating's performance are not determined until the coating has received at least 18 months of exposure, preliminary results after 1 year of beach exposure are showing some interesting facts. The repair program results have clearly identified a few inorganic zinc-rich coatings and methods of surface preparation that are most likely to be successful. Currently, the stainless steel coatings are performing well; however, none of these coating systems are withstanding the acid treatment on the aluminum. It can be seen now that most of the zinc-rich inorganic coatings tested in this program may be expected to perform well in the marine environment of KSC but cannot handle the acid solid-rocket-booster effluent. The epoxy tie-coat/polyurethane topcoatings recommended by most paint manufacturers for acid resistance are not performing well in the marine environment at KSC. The only successful topcoat at this point in the study is Amercoat 741, an inorganic topcoat, and it represents a very limited selection of prospective protective topcoats. As a result, future studies will be performed in order to investigate other possible protective topcoat systems.

D. J. Ruggieri, 867-4614 DE-MAO-2

Orbiter Thermal Protection System (TPS) Waterproofing

The Shuttle Orbiter TPS tiles absorb water unless they are protected with a waterproof coating. After a first flight, the manufactured protection diminishes, and the tiles must be rewaterproofed. For the initial test flights, rewaterproofing was done by spraying a solution on the tiles; however, the effectiveness diminished after exposure to rain. The current rewaterproofing method uses injection of a waterproofing chemical into the tiles. Neither method's waterproofing chemical will withstand reentry temperatures. The net effect is that each Orbiter requires rewaterproofing of the TPS tiles after each flight. The procedure is expensive and time consuming.

It was determined through a recently completed industry survey that chemicals that will withstand reentry temperatures are now becoming available. Additional effort is planned to develop a new waterproofing system using the new chemicals capable of withstanding high temperatures to provide permanent protection.

F. E. Jones, 867-2713   SE-MSD-11

Biomedical

Performance Assessment and Work Force Epidemiology

A continuing program of physiological testing of the Kennedy Space Center worker includes a systematic assessment of physical health status and work capacity. The epidemiological monitoring of the impact of space industry occupations is conducted by descriptive analysis of the work force and identification of special subsets of workers such as firefighters, high crew, and propellant handlers. Individual requirements of these and other special job categories are assessed and measured in order that proper physical standards can be specified and maintained. In addition, a program was devised to determine the physiological costs of occupations central to launch and landing operations. Evaluation of workload and the effect of the Florida environment, as well as the physiological cost of wearing protective gear and/or ensembles, is studied in terms of the body's cardiorespiratory, metabolic, and thermoregulatory systems.

D. F. Doerr, 867-3152   MD-BEB

Protective Equipment Physiological Testing

Processing of the Space Shuttle and other spacecraft often requires workers to be protected from toxic vapors and liquids such as propellants. Overall operational efficiency depends upon the ability of the workers to perform tasks while wearing protective gear. Candidate respiratory protective equipment is evaluated in the Biomedical Laboratory to determine its ability not only to meet the physiological requirements of the worker under stress conditions but also to provide the

necessary protection. Self-contained breathing apparatus and short-duration emergency air-supply units are tested for air-supply duration, physiologic effect, and the quality of the internal environment during treadmill-simulated work conditions.

Whole-body protective apparatus, such as self-contained atmospheric protective ensemble, have been in use with NASA and the Air Force for over 20 years. Little has been known about the physiological impact of these suits during work and adverse (cold and hot) environmental conditions. A systematic study of the physiological responses of workers in laboratory and field-operation settings is currently in progress. Information recently developed from this study will be used to verify performance of the new propellant-handlers' ensemble, which will replace the previously mentioned self-contained atmospheric protective ensemble.

D. F. Doerr, 867-3152   MD-BEB

Engineering Management and Training Aids

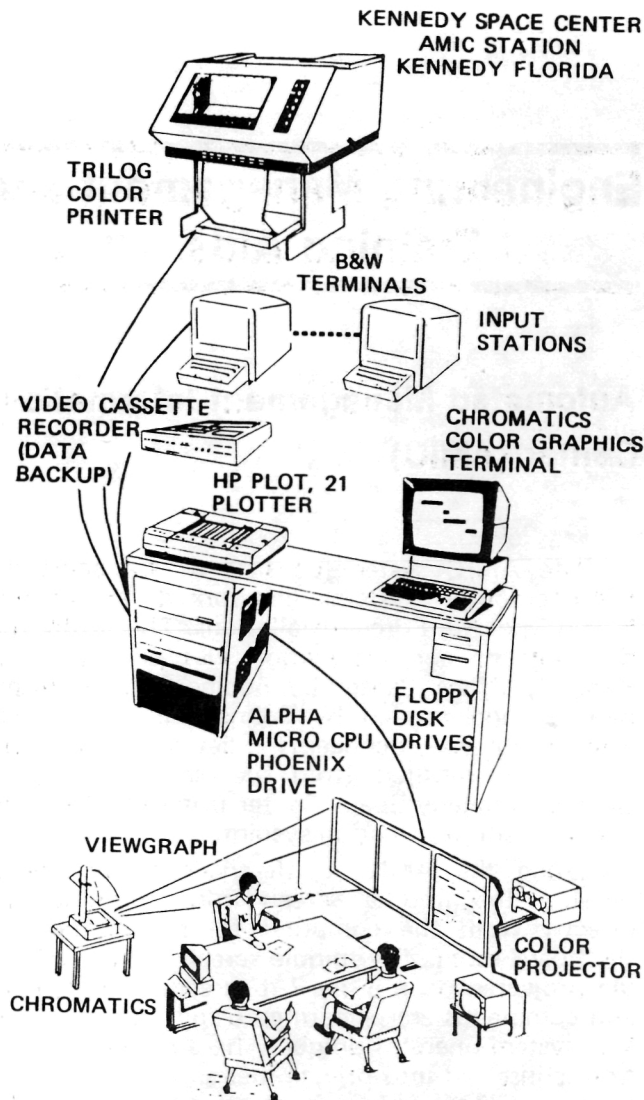## Automated Management Information Center (AMIC)

The AMIC system consists of six operating microcomputer systems networked at various NASA and Air Force installations. The prototype development and installation was performed at Kennedy Space Center by Boeing Services International and funded by Johnson Space Center. The prototype, concepts, development, and installation resulted from successful demonstrations at Kennedy Space Center using the Kennedy management information system.

Using the AMIC, conferences are enhanced because the middle screen information comes directly from the computer for presentation to the board room. The middle screen shows a schedule projected on a 5- by 7-ft screen. The controls and commands are performed using the keyboard. The system operates uniquely because all information is inserted into private files and then reviewed by management before it is converted into public (or common) information. This permits a manager to validate and review the information prior to submission to other sites.

The initial process begins by entering the system via the menu to create a new title that becomes the title of the chart, establishes the data base item, and simultaneously adds the title to a menu. This unique process makes the system extremely user friendly and easy to use by the manager himself.

Next, the data are keyed (or retrieved from another computer) to create the individual bars or events. The final step is to depress the GO button to create the chart automatically in color to viewgraph (acetate) form directly from the X-Y plotter. Another option exists to transmit electronically within 45 s to another location and/or to project the chart on a large (6- by 8-ft) screen using a color projector.

The system also contains a powerful word processor and some office automation capabilities. It permits sending mail via the GTE TELEMAIL sys-

KENNEDY SPACE CENTER
AMIC STATION
KENNEDY FLORIDA

TRILOG
COLOR
PRINTER

B&W
TERMINALS

INPUT
STATIONS

VIDEO CASSETTE
RECORDER
(DATA
BACKUP)

HP PLOT, 21
PLOTTER

CHROMATICS
COLOR GRAPHICS
TERMINAL

ALPHA
MICRO CPU
PHOENIX
DRIVE

FLOPPY
DISK
DRIVES

VIEWGRAPH

COLOR
PROJECTOR

CHROMATICS

A typical AMIC installation.

tem and/or transmitting using TELENET. However, bulletin board messages, notes, letters, etc. are transmitted via the menu, with the capability to interlace graphics pages into text files, thus providing a much easier communications tool to use and control.

The system's major software development benefit is the capability to deliver all the documentation, software, data bases, user's manuals, and instructions using a standard video cassette recorder (VCR) (VHS, Betamax, or equal). The $9 VCR tape cartridge replaces the old $200 disk packs used by most data systems. Over 90 Mb of information can be stored on one tape, and the VCR also serves as a backup device, thereby eliminating the expensive nine-track tape drives used by most systems. Additionally, the reduced storage area of

the VCR tapes vs. computer nine-track tapes and disk packs allows the operator to keep them in a desk drawer.

M. J. Martin, 867-3225   SP-SAI-A

An AMIC work station in use.

Application of Voice-Interactive Maintenance-Aiding Device (VIMAD) Technology

Kennedy Space Center (KSC) has initiated a study effort with Honeywell, Incorporated, to determine if the elimination of paper documentation is feasible for certain KSC operations by using an improved VIMAD. The VIMAD concept, developed by Honeywell under contract to the Defense Advanced Research Projects Agency, became feasible after development of a video disc that can store thousands of still photos and brief movies to show how to perform maintenance operations. The stored data are recalled and sequenced by voice command to the computerized control center. It is then displayed on a miniature television set that is part of the operator's headset.

Initial investigations into the feasibility of applying the VIMAD technology at KSC were conducted during the past year. Several areas of payload processing were determined to be amenable to substantial improvement through VIMAD applications. In addition, the potential for integrating the VIMAD and expert systems technologies was established. Further contractual effort is continuing. A prime candidate for the first application is Level IV Spacelab payload integration.

J. B. Lansing, 867-4493   SF-ENG

PROJECT REFERENCE DATA

ITEM	RESPONSIBLE INDIVIDUAL	PARTICIPATING ORGANIZATION	NASA HEADQUARTERS SPONSOR
Magnetic Reliquefaction of Hydrogen	F. S. Howard 867-3202 DD-MED-4	Los Alamos National Laboratories	AD/CDDF
Capture of Liquid Hydrogen (LH_2) Boiloff Using Metal Hydrides	F. S. Howard 867-3202 DD-MED-4	Ergenics	AD/CDDF
Study of Systems and Technology for Liquid Hydrogen Production Independent of Fossil Fuels	W. H. Boggs 867-2133 DD-FED	E:F Technology	AD/CDDF
Flex Hose Flow-Induced Vibration Testing	F. N. Lin 867-4156 DD-MED-4	Planning Research Corporation Georgia Institute of Technology	OSF
Mathematical Model for Estimating Transient Pressure Surges in Cryogenic Liquid-Vapor Systems	F. N. Lin 867-4156 DD-MED-4	Planning Research Corporation University of Central Florida	OSF
Computer Simulation of External Tank (ET) Liquid Oxygen (LO_2) Vent System	A. F. Rodriguez 867-3339 DD-MED-43	Planning Research Corporation	OSF
Cryogenic Quick-Disconnect (QD) Coupling Development	G. E. Reichle 867-7585 DD-MED-31	Planning Research Corporation	OSF
Hypergolic Packed-Column Counterflow Vapor Scrubber Test Program	H. E. Peete 867-3206 DD-MED-41	Planning Research Corporation Research Triangle Institute	OSF
Distillation and Recovery Processing of Nitrogen Tetroxide (N_2O_4)	K. S. Ahmie 867-7960 DD-MED-41	Planning Research Corporation	OSF
Nitrogen Tetroxide (N_2O_4) Thermophysical Properties Tables	F. S. Howard 867-3202 DD-MED-4	National Bureau of Standards	OSF

ITEM	RESPONSIBLE INDIVIDUAL	PARTICIPATING ORGANIZATION	NASA HEADQUARTERS SPONSOR
Remote Sensing of Hydrazines	P. M. Rogers 867-3086 DL-DED-32	Jet Propulsion Laboratory	AD/CDDF
Improved Parts per Million (PPM) and Percent Level Hydrogen Detection in Inert Atmospheres	W. R. Helms 867-4449 DL-NED-3	Catalyst Research Corporation	OSF
Improved Low-Level Portable Survey Instrument for Hydrazine Detection	W. R. Helms 867-4449 DL-NED-3	Energetics Science	OSF
Hazardous Gas Detection	W. R. Helms 867-4449 DL-NED-3		OSF
Improved Leak-Check Methods of the Shuttle Main Propulsion Systems	W. I. Wiley 867-3197 SE-FSD-1		OSF
Heat Transfer in an Unsteady Turbulent Airflow Across a Section of the Shuttle External Tank (ET)	F. N. Lin 867-4156 DD-MED-43	Planning Research Corporation	OSF
Application of Infrared Imaging to Convective Cooling Equipment Design	W. K. Lackie 867-2261 SE-PEO		OSF
Solid Rocket Booster (SRB) Towing-Simulation Computer Program	R. E. Wickham 867-7594 DD-MED-32	Planning Research Corporation	OSF
Centaur Rolling Beam Umbilical System (RBUS)	G. E. Reichle 867-7585 DD-MED-31	Planning Research Corporation	OSF
Language for User Control and Communication (LUCC) for Space Station Operations	A. Dorofee 867-4430 DL-DED-22		OSF
Software Verification and Validation Tools for the Launch Processing System (LPS)	L. E. Morgan 867-4430 DL-DED-22	Harris Corporation	OSF

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Pisces - Launch Processing System (LPS) Computer Replacement	R. D. Luken 867-3086 DL-DED-3	Martin Marietta Corporation	OSF
Orbiter Functional Simulator	E. G. Sherrill 867-3645 CP-GSO		OSF
Artificial Intelligence Research	R. C. Delaune 867-4935 SC-LPS-2	Mitre Corporation	AD/CDDF
High-Speed Digital Multiplexer/Demultiplexer Development	T. L. Herring 867-3842 DL-DED-32	Martin Marietta Corporation	OSF
Fiber-Optic Transmission System	M. Padgett 867-3367 DL-NED-1		OSF
Mesoscale Atmospheric Simulation System (MASS) — Kennedy Space Center (KSC) Weather Prediction Modeling	R. P. Wesenberg 867-4438 DL-NED-31	Langly Research Center Goddard Space Flight Center	OSF
Lightning Protection Using Flux-Cancellation Techniques	R. P. Wesenberg 867-4438 DL-NED-31		OSF
Application of Kennedy Space Center (KSC) System Assurance Analysis (SAA) Methodology to Nuclear Power Plant Designs	D. W. Page 867-3402 DL-NED-21	Nuclear Regulatory Commission Duke Power Company	OER
Demonstration to Simulate Nuclear Power Plant Operation Using Kennedy Space Center (KSC) Software Control Concepts	D. W. Page 867-3402 DL-NED-21		OER
Multispectral Analysis of Nuclear Magnetic Resonance (NMR) Imagery	R. L. Butterfield 867-3017 PT-TPO	Washington University University of Florida	OER

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Evaluation of a Photo-voltaic-(PV)-Powered Water Electrolyzer	G. L. Reuterskiold 867-3324 DD-MED-43	Florida Solar Energy Center	OER
Prototype Cellulose Conversion System	S. S. DiPasquale 867-3335 DD-MED-43	University of Florida	OER
Feasibility Analysis of a High-Efficiency Dehumidifier Air-Conditioner Using Heat Pipes	R. C. Koning 867-3688 DD-FED-33	Florida Solar Energy Center Research Triangle Institute Econ, Incorporated	OER
Demonstration of the Light-Activated Reduction of Chemicals (LARC) Process for the Decomposition of Polychlorinated Biphenyl (PCB)	J. V. King 867-2196 DD-FED-21	Atlantic Research Corporation	OSF
Prototyping a Personnel Emergency Egress Vehicle	F. E. Lundy 867-2759 DD-MED-42	Planning Research Corporation	OSF
Invar Weld Testing	S. W. Walker 867-7969 DD-MED-43	Planning Research Corporation	OSF
Protective Coating Systems for Carbon Steel, Aluminum Alloys, and Stainless Steel	D. J. Ruggieri 867-4614 DE-MAO-2		OSF
Orbiter Thermal Protection System (TPS) Waterproofing	F. E. Jones 867-2713 SE-MSD-11		AD/CDDF
Performance Assessment and Work Force Epidemiology	D. F. Doerr 867-3152 MD-BEB		OSSA
Protective Equipment Physiological Testing	D. F. Doerr 867-3152 MD-BEB		OSF
Automated Management Information Center (AMIC)	M. J. Martin 867-3225 SP-SAI-A	Boeing Services International Johnson Space Center	OSF

ITEM	RESPONSIBLE INDIVIDUAL	PARTICIPATING ORGANIZATION	NASA HEADQUARTERS SPONSOR
Application of Voice-Interactive Maintenance-Aiding Device (VIMAD) Technology	J. B. Lansing 867-4493 SF-ENG	Honeywell, Incorporated	OCE/OSF

AD/CDDF = Deputy Administrator/Center Director's Discretionary Fund
OCE   = Office of the Chief Engineer
OER   = Office of External Relations (Technology Utilization)
OSF   = Office of Space Flight
OSSA   = Office of Space Science Applications

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15. Abstract

As the NASA Center responsible for assembly, checkout, servicing, launch, recovery, and operational support of Space Transportation System elements and payloads, Kennedy Space Center is placing increasing emphasis on the Center's research and technology program. In addition to strengthening those areas of engineering and operations technology that contribute to safer, more efficient, and more economical execution of our current mission, we are developing the technological tools needed to execute the Center's mission relative to Space Station and other future programs. In connection with the increasing emphasis on research and technology, the directorate of Design Engineering has been expanded in scope and is now designated the directorate of Engineering Development. The new directorate encompasses most of the laboratories and other Center resources that are key elements of research and technology program implementation and is responsible for implementation of the majority of the projects in this 1983 Annual Report. The report contains brief descriptions of research and technology projects in major areas of Kennedy Space Center's disciplinary expertise.

For further technical information about the projects, contact Albert E. Jorolan, Engineering Development, Research and Technology Manager, DL-RT, (305) 867-7476. James M. Spears, Chief, Technology Projects Office, PT-TPO, (305) 867-7705, is responsible for publication of this report and should be contacted for any desired information regarding the Center-wide research and technology program.

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National Aeronautics and
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Washington, D.C.
20546

Mr. Clarence H. Perisho
Chief Technology Engineer-
Structural Dynamics
McDonnell Douglas Corporation
Bldg. 32, Room 374
P.O. Box 516
St. Louis, MO   63166

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